THE MAGB "DSEAR" GUIDE

TO ASSIST MALTSTERS' COMPLIANCE WITH THE DANGEROUS SUBSTANCES AND EXPLOSIVE ATMOSPHERES REGULATIONS 2002

Produced by an MAGB expert workgroup.

SECTION FOUR of this report and the work it describes were reviewed and edited by the Health and Safety Laboratory under contract to the Maltsters Association of Great Britain. Its contents, including any opinions and/or conclusions expressed or recommendations made, do not necessarily reflect policy or views of the Health and Safety Executive

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Introduction to the MAGB Guide to DSEAR

In the UK there has not been a loss of life due to an explosion in a maltings, and the most significant reasons for this are careful equipment selection, planned preventative maintenance and GOOD HOUSEKEEPING. If dust deposits are not allowed to emanate or accumulate anywhere in the maltings, then the potential explosion hazard is significantly reduced. This must always be taken fully into account when making any site assessment or compliance check.

The MAGB approach centres on evaluating the dust explosion risk in operating equipment. The basis of the approach is that any risk will occur only in certain types of equipment, and outside that defined location the area zoning can be considered as SAFE.

The key issue to remember is that a dust explosion has two potential stages:
1) The first stage is the PRIMARY explosion, where an ignition source comes into contact with a dust cloud of sufficient density to support an explosion.
2) If there is sufficient depth of dust or fines deposited in the area of the force of this primary explosion, then this can produce a major dust cloud which immediately leads to a much larger SECONDARY explosion, which can cause substantial damage, and loss of life.

This guide is written for those carrying out risk assessments to prevent both primary and secondary dust explosions, and to advise what is needed for full compliance under the Dangerous Substances and Explosive Atmospheres Regulations (DSEAR). It is the work of many experts, both theoretical and practical, and is written to act as an industry guidance document for all malting sites.

The guide is constructed in four main parts, and as the reader moves forward through the Guide each section provides more information and support for the section that preceded it.

The First Section of the Guide is an example of a simple standard assessment sheet that can be photocopied and completed by a competent or suitably qualified person or team for use in dust explosion risk assessment in connection with DSEAR Regulations.

An alternative means of logging an entire site's DSEAR evaluation is by using the MAGB DSEAR Excel spreadsheet, available from the MAGB secretariat on request.

The Second Section details how the MAGB working group considered the zoning of maltings plant, and have indicated a classification for all the different equipment based on the material it will be handling.

The Third Section deals with how those zoning decisions have been reached, and the details of the ignition hazard and hence potential explosion risk on each piece of plant in use in a maltings, operating under a range of conditions from normal operations, expected malfunction to rare malfunction.

The Fourth Section deals with the Regulations themselves, and the requirements for compliance. This section was written by the MAGB with assistance from nabim (National Association of British and Irish Millers), for which the malting industry is most grateful. The Fourth Section was then reviewed and edited by the Health and Safety Laboratory, to result in the version now included in this Guide.

Acknowledgements are due to the following member of the MAGB DSEAR workgroup: (listed in alphabetical order)

Dave Coghill	**Diageo Scotland Ltd**
Roger Bishop	**Bairds Malt Ltd**
Richard Broadbent	**Bairds Malt Ltd**
Bruce Johnson	**Crisp Malting Ltd**
Alan Malcolm	**Simpsons Malt**
Steve Mulford	**Crisp Malting Ltd**
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SECTION 1 MAGB Guide to DSEAR

Specimen hazard risk assessment form Sheet 1 of

Please make copies of this document for site assessment checks.

ALTERNATIVELY use the MAGB DSEAR spreadsheet (available on request from the MAGB secretariat) to record the full site assessment.

Assessment title	

Item of plant or operation being assessed.	

Names of the responsible person or persons carrying out the assessment	

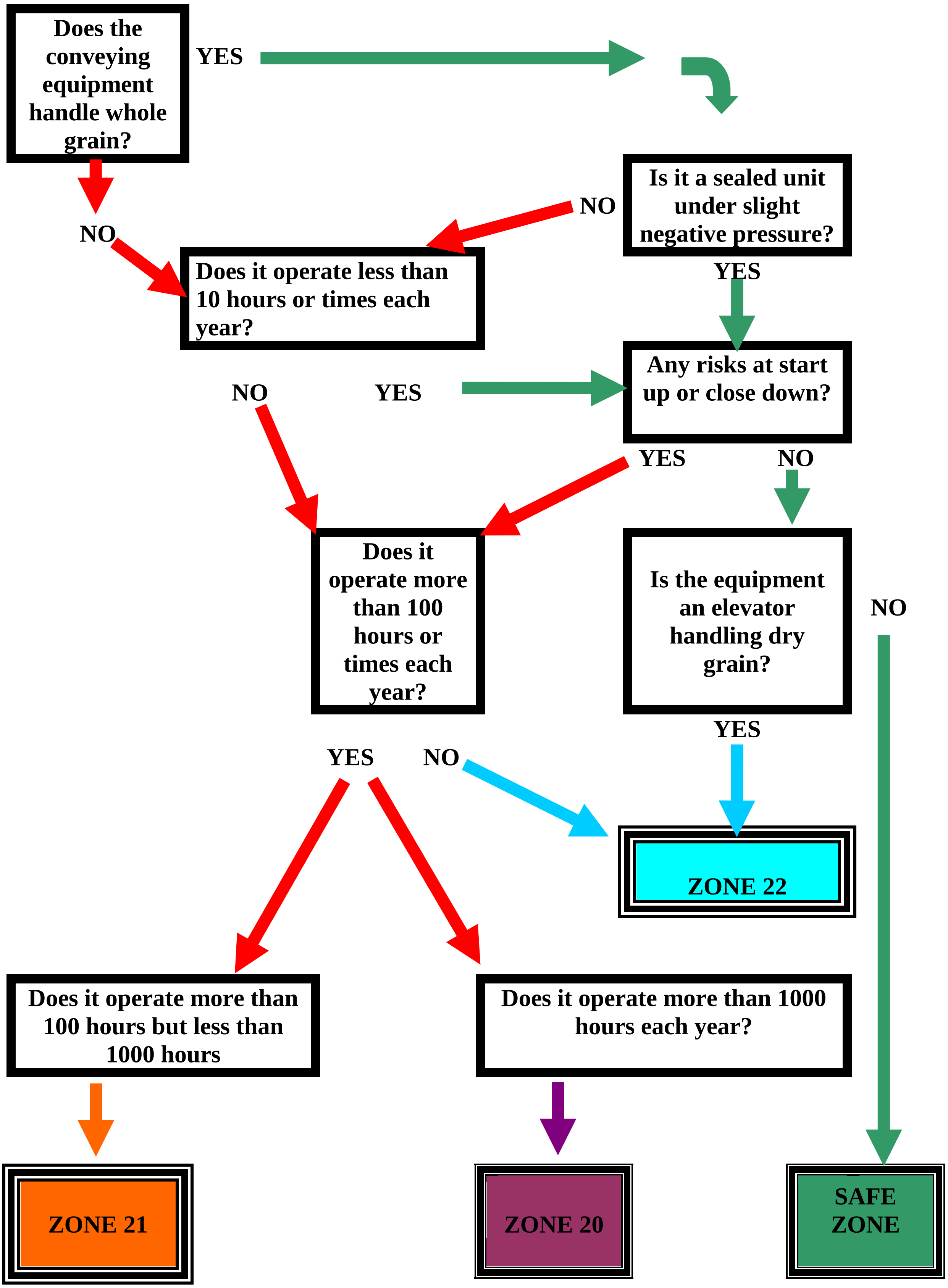
Brief description of the Plant/Process/Operations/Materials being processed. (To indicate the situation covered by the assessment and the safety measures involved)	

Details of the assessment, the information considered, the risk evaluation and the selected basis of safety

CONCLUSIONS REACHED	
The basis of safety (what should be done to ensure minimal and/or reasonable risk.	
Decision on ZONING	
Any specific comment on the design, operation, and maintenance of the relevant equipment in use in the hazard being evaluated?	
SIGNATURE	
DATE	

Note: Guidance on risk assessments for different items of maltings plant are given in Sections 2 and 3 of the MAGB Guide to DSEAR.
Section 4, point 4 of the MAGB Guide to DSEAR also details 'Documentation'.

MAGB GUIDANCE DIAGRAM to help DSEAR assessments.



SECTION 2

Hazardous Area Classification Data Sheets

This section gives the MAGB expert workgroup's decisions on zoning guidance for maltings plant.

NOTE The malting industry tends to refer to very small particle size material as FINES rather than DUST.

Hazardous Area classification data sheet Part I Flammable material list and characteristics								
Flammable material	LEL (gm^{-3})	Minimum cloud ignition temp (°C)	Minimum ignition energy (mJ)	Minimum layer ignition temperature (°C)	Equipment Temp. Class	Kst ($barms^{-1}$)	Pmax (bar)	Comments
Barley Fines	40-50	440-450	30-100	300	T2	93	8.7	Dust explosion St Class 1
Malt Fines	60*	400*	>500*	275	T3	178	9	Dust explosion St Class 1
Malt Grist	-	380*	-	300*	T2	153	9.7	
Wheat Fines		430						Dust explosion St Class 1
Wheat Flour		430						
Dark grains Fines	-	450	-	405	T2	110	8.4	
Malt culms	-?	-?	-	-?	-?	-	-	

* Information from standard data

- Information not currently available. To be sampled and analysed

Dust Explosion Classification: St Class 1 Dusts are considered to be 'weak to moderately explosive', See APPENDIX 2 of SECTION 4 for more information.

Evaluating the various areas in a malting plant in terms of DSEAR Zoning for potential hazard.

Hazardous area classification data sheet

Part II: List of sources of release

Section 1 - Internal spaces of plant and machinery

	Source of release	Release Description	Material handled	Grade of release	Zone type	Zone Extent	Comments
1	Internals of Screw Conveyor	No release	Barley/Malt/ Pellets/culms	N/A	Safe Area	Internals of Machine	Material has very low fines content, conveyor runs half full and is slow moving – not much agitation of material – will not create fines in suspension. The self cleaning operation of the machine means that fines layers can't form inside the equipment.
2	Internals of Screw Conveyor	No release	Green Malt	N/A	Safe Area	Internals of Machine	Material has high moisture content – no fines created
3	Internals of Screw Conveyor	Falling product at inlet and discharge chutes may create fines in suspension.	Fines/grist/ flour	Secondary	22	Internals of Machine	Seen as more likely to have flammable fines cloud than conveyors handling malt/barley, however it is still considered unlikely that a flammable fines cloud will be present in normal operation. Observation of screw conveyor operation has demonstrated that fines normally move in a smooth flow without generating a fines cloud. Abnormal conditions (including external explosions etc could raise the material into suspension) could lead to zone 22.

4	Internals of Screw Conveyor (above fines collection hopper)	Falling fines at inlet and discharge chute.	Fines	Continuous	20	Internals of Machine	Due to operation of fines hopper, fines may remain in suspension at discharge of screw leading to zone 20.
5	Internals of Screw Conveyor (inside surge hopper and fines collection bin)	When hopper/bin is running empty, screw will be more likely to be in combustible fines atmosphere	Fines	Primary	22	Internals of machine	In normal operation the screw will be covered completely in fines, which precludes a combustible atmosphere. When bin is running empty (abnormal conditions), conveyor may be exposed to combustible atmosphere.
6	Internals of Drag Link Conveyor	No release	Barley/Malt/ Pellets/Wheat	N/A	Safe Area	Internals of Machine	No fines generated due to low fines content of material and slow speed of machine (based on design and observation of operation). Cannot increase speed of conveyor or amount of fines in system therefore abnormal conditions are not foreseeable. The self cleaning nature of the machinery results prevents layers of fines forming.
7	Internals of Drag Link Conveyor	Falling fines at inlet and discharge chute.	Fines/grist/ flour	Secondary	22	Internals of Machine	Slow movement of machine leads to smooth flow and no fines cloud generation (observed). Potential for fines clouds at inlet and discharge chutes in abnormal conditions.
8	Belt Conveyors	No release	Green Malt	N/A	Safe Area	None	Product is damp therefore no fines generated leading to safe area classification.
9	Belt Conveyors	No release	Malt/Barley	N/A	Safe Area	Internals of Machine	No agitation of malt whilst on belt and low fines content of material therefore no fines created. Feed onto belt is through chute with very little fines generated – flammable concentration not foreseeable.
10	Internals of Pneumatic fines Conveyors	Fines in suspension within pipe work during conveying operations	Fines	Continuous	20	Internals of Machine	Running constantly Heavy concentration of fines within pipe work.

11	Internals of Belt and Bucket Elevators	Abnormal conditions only.	Barley/Malt/ Wheat	Secondary	22	Internals of Machine	Fines present in suspension during normal operation but not an explosive atmosphere. Due to the speed and design of the machine and the relatively large internal spaces it is foreseeable that in very abnormal conditions a combustible atmosphere may be present. This is a conservative view.
12	Internals of Belt and Bucket Elevators	N/A	Pellets	N/A	Safe Area	Internals of Machine	Pellets have virtually no associated fines content.
13	Internals of Belt and Bucket Elevators	Fines generated at outlet of elevator.	Fines & Culms Mixture	Primary	20	Internals of Machine	In normal operation product contains 60% culms and 40% fines mixed. Unlikely to be a combustible atmosphere. Fines and culms may be separated at outlet of elevator. In extraordinary circumstances, product could be fines alone, when there is a possibility of a combustible atmosphere.
14	Internals of Belt and Bucket Elevators	Product has high fines content.	Grist/Fines	Continuous	20	Internals of Machine	High probability of continuous fines cloud due to operation of machine and material being handled.
15	Internals of Chain and Bucket elevator	No release	Green Malt Only	N/A	Safe Area	Internals of Machine	Product is damp therefore no fines generated leading to safe area classification.
16	Internals of Drag-link Elevayor	No release	Malt/barley/ wheat	N/A	Safe Area	Internals of Machine	No fines generated due to low fines content material and slow speed (based on design and observation of operation). Cannot increase speed of conveyor or amount of fines in system therefore abnormal conditions are not foreseeable. Self cleaning action prevents build up of fines layers.

17	Internals of Drag-Link Elevator	Falling fines at inlet and discharge chute.	Fines/grist	Secondary	22	Internals of Machine	Slow movement of machine leads to smooth flow and no fines cloud generation (observed). Potential for fines clouds at inlet and discharge chutes.
18	Internals of flat bed dresser	Disturbance of fines layers	Barley/malt	Secondary	22	Internals of Machine	Very little fines in suspension during normal operation (observed). Observation showed that layers of fines will build up on surfaces of machine. External event required to disturb fines layers.
19	Internals of Rubble Separator/Barley cleaner	N/A	Barley	N/A	Safe	Internals of Machine	No fines generated and no fines layers within machine (open to atmosphere). No layering of fines inside machine to lead to a combustible atmosphere in abnormal conditions.
20	Rotary Dresser (Rotaclean)	Fines present from inlet	Barley/Malt	**N/A**	Safe	Internals of m/c	With aspiration and low machine speed
21	Internals of De-Culmer	No release	Malt & Culms	N/A	Safe	Internals of m/c	Fines generated in machine but not of flammable concentration.
22	Internals of Pellet Mill	Fines present at inlet of machine in abnormal conditions	Culms/Fines	Primary	21	Internals of Machine	High concentration of fines and culms (60:40) in suspension at inlet to die (normally the machine runs full, precluding a combustible atmosphere). There will however be periods where the machine will not be running full leading to a zone 21 area. Not possible to observe when running.
23	Internals of Conditioning Unit (Turbo Mix)	Falling fines at inlet and discharge chute.	Culms/Fines	Primary	21	Internals of Machine	In normal operating conditions machine contains fines and culms mixture (60:40). In abnormal conditions, can be fines only going through machine leading to zone 21 classification. More agitation than a screw conveyor and therefore more likely to contain flammable atmosphere. Not possible to observe when running.

24	Internals of Pellet Shaker	No release	Pellets	N/A	Safe	Internals of Machine	Machine is open to atmosphere and handles pellets. As such, proportion of fines is very low and will not create a flammable fines cloud.
25	Internals of Pellet Screening Screw	No release	Pellets	N/A	Safe	Internals of Machine	Similar to screw conveyor but with screen at bottom. Fines content of material is very low in normal operation. Minimal agitation.
26	Internals of Pellet Cooler	No release	Pellets	N/A	Safe	Internals of machine	Machine is open to atmosphere. Contents are tightly packed, slow moving pellets. As such, fines content is negligible.
27	Internals of Rotary Valves (Fines Collection System)	Fines in suspension	Fines/Culms	Continuous	20	Internals of Machine	Designed as explosion choke. Vanes may not run full during operation resulting in small pockets of fines in suspension. Zone 20 – conservative view. Not possible to observe when running.
28	Internals of Rotary Valves (Barley/Malt Handling)	No release	Malt/Barley	N/A	Safe	Internals of Machine	Designed as explosion choke, low fines content material being handled. Small internal spaces, which will be full in normal operation resulting in no fines in suspension.
29	Fines extraction system pipe work	Abnormal conditions could lead to layers of fines developing	Fines	Secondary	22	Internals of duct work	In normal operation, fines concentration is below the lower combustible limit. Fines systems are design so that the fines concentration is limited and the speed of transfer is such to keep the fines in suspension. This is confirmed by regular testing. Very occasionally abnormal conditions arise where flow reduces or stops leading to the build up of layers which could be roused into a combustible cloud if disturbed. Not possible to observe when running.

30	Internals of Fines Extraction Filter Unit	Fines in suspension	Fines	Continuous	Dirty side – zone 20 Clean Side – zone 22	Internals of Machine	High level of fines in suspension almost continuously in dirty side of filter - Zone 20. Clean side rated as zone 22 to cover abnormal failure of filter. This will include the exhaust air duct and a 1m area around the end of the duct. Note:- external explosion relief duct and 1m area at end of duct will be zone 22 (abnormal event of failure of relief panel).
31	Internals of Fines Cyclone	Fines in suspension	Fines	Continuous	20	Internals of Machine	While machine is running there will be small areas of high concentration of fines which will be present frequently. Layering effect as fines falls out of suspension. Note :- cyclones external explosion relief duct and 1m area at end of duct will be Zone 22 (abnormal event of failure of relief panel). Not possible to observe when running.
32	Internals of Weigher (Inline/Electric)	No release	Malt/Barley/ Wheat	N/A	Safe	Internals of Machine	No moving parts within machine. The grain flows through a vertical tube which runs full 99% of time. Minimal content of fines in grain results in no possibility of flammable atmosphere. Not possible to observe when running.
33	Internals of Weigher (Mechanical)	Disturbance of fines layers	Malt/Barley/ Wheat	Secondary	22	Internals of Machine	Weigher action does not create areas of fines cloud in normal operation, however fines layers do build up within machine Zone 22 due to fines layers.
34	Internals of Steeps (only during filling)	No release	Barley	N/A	Safe	Internals of vessel	Water is introduced to the steep, prior to filling with dressed grain. Not feasible to create explosive fines cloud due to minimal content of fines in barley.

35	Internals of maltings Germination vessels	No release	Green Malt	N/A	Safe	Internals of Vessel	No fines present as material has high moisture content. Not zoned
36	Internals of Kilns (above bed)	No release	Green Malt/Malt	N/A	Safe	Internals of Vessel	Fines layers are limited to a very small proportion of the overall area and are minimal (thin film after six months<1mm) therefore an explosive fines cloud cannot be created even if disturbed. Very small amounts of fines generated during kilning or stripping. Any fines in kiln will be in saturated air during drying operation. Not feasible to create explosive fines cloud.
37	Internals of Kilns (Below Bed)	No release	Culms/Fines	N/A	Safe	Internals of Machine	Although there is a degree of material (consisting of a very high percentage of culms) layering on surfaces, particle size analysis confirms that it is not feasible to create an explosive fines cloud.
38	Internals of Kiln Loader/Stripper	No release	Green Malt/Malt	N/A	Safe	Internals of Machine	Conveys green malt when loading therefore no fines is generated. When stripping, the product drops into a drag link conveyor which is slow moving and creates little fines when moving
39	Internals of Self Emptying Malt/Barley Silos	No release	Malt/Barley	N/A	Safe	Internals of Silo	Testing of atmosphere whilst filling silos indicated a maximum fines concentration of 2.7 gm^{-3}. Some fines layering can occur in the head space of the silos (top 1.5m).
40	Internals of Pre-Steep Bins	No release	Barley	N/A	Safe	Internals of Machine	Handling the same product as the storage bins therefore conditions should be the same.

41	Internals of Flat Bottomed Silos	No release	Barley/Malt	N/A	Safe/22	Internals of Silo	Depending on type of equipment. Silos are stand alone, with no fines extraction fitted – just vents. Very similar to self-emptying silos.
42	Internals of Pellet Bins	No release	Pellets/Culms /Fines	N/A	Safe	Internals of Machine	Very little fines created, material in hard pelletised form.
43	Internals of Fines Collection and fines feed Bins	Fines in suspension due to process.	Fines	Continuous	20	Internals of Machine	Fines present in suspension for long periods of time.
44	Internals of Culms Bin	Layers of fines within bin	Culms	Secondary	22	Internals of Machine	Unlikely to be much fines created due to low percentage of fines in material, however thin layers of fines build up on bin sides. Conservative view is zone 22. Will only create combustible atmosphere if disturbed by external events (e.g. explosion elsewhere).
45	Internals of Combined Fines and Culms Bin (pellet mill surge hopper)	Product includes high percentage of fines.	Culms/Fines	Continuous	20	Internals of Machine	There could be regular instances when fines only are entering the bin. Observation showed no flammable atmosphere, however due to material, flammable atmospheres are likely.
46	Internals of Flat Bottomed Barley Store	Layers of fines on beams etc.	Barley	Primary	22	Internals of building	Possible build up of fines on handrails and ledges following filling operations – House keeping operations are normally restricted to once a year.
47	Internals of off-kiln/analysis Bins	No release	Malt	N/A	Safe	Internals of m/c	Same conditions as the self-emptying bin.
48	Internals of Malt Dispatch Bins	No release	Malt	N/A	Safe	Internals of Machine	As for self emptying bins. Material will have lower fines content (will have passed through a dresser).

49	Filling Malt Lorries	Negligible release of fines	Malt	N/A	Safe	Internals of Machine	Fines visible in close proximity to discharge point, but not thick enough to be explosive. Good ventilation, which dissipates fines quickly.
50	Fixed vacuum cleaning system	Fines within collection unit	Fines	Primary	21	Internals of machine	Vacuum unit runs as needed. Typically this is 2 hours a day. Non-continuous use leads to Zone 21 on dirty side of air filter.
51	Grist bin (if malt milling occurs at maltings)	Fines content of grist falling to bottom of bin	Grist	Primary	20	Internals of bin	Observation of bin filling has demonstrated that during filling the extent of the zone 20 area is limited to the immediate area of the falling product
52	Grist bin breather/filter unit	Flammable fines cloud may be present, most likely during shaker operation.	Grist	Primary	21	Zone 21 on dirty side of filter. Zone 22 on clean side	Shaker operates for a few minutes every grind. At other times a flammable fines cloud is unlikely to be present. A zone 22 area will exist on the clean side of the filter to account for the abnormal failure of the filter socks.
53	Mill (roller and hammer types)	Machine creates grist/ Flour downstream of rollers/hammers	Grist/Flour	Primary	20	Down stream of rollers/ hammers	Upstream of the rollers/hammers will be Zone 21 (accounts for the frequent but short duration of start up/shutdown periods). Downstream of the rollers/hammers will be Zone 20.
54	Malt roasters (if specialist coloured malts made at the maltings)	Minimal amounts of fines can be released as the drum is being filled dependent on the product being roasted	Barley/malt	Primary	22	Internals of machine	The risk only applies to the drum internal which is not a closed system
55	Malt roasters	No release	Green malt	Primary	Safe	Internals of m/c	The product produces no fines

SECTION 3

Mechanical plant risk assessment

This section lists the detailed consideration that has been given to the potential risks of malting equipment operation, and covers three conditions:

1) Normal operation of the malting equipment
2) Expected malfunction, what is likely to happen if normal operation fails.
3) Rare malfunction, the ‘worst case’ scenario, which is unlikely to happen in practice.

The information in this section was considered in combination with materials being handled to produce the ZONING guide shown in SECTION 2.

1. Screw conveyor

These conveyors generally handle barley and malt products giving rise to an internal zone 22 area. In general the area outside the casing is not defined as a hazardous area.

These machines are usually driven by general purpose industrial electric motors. In most applications, the machine is driven through a gear box but some machines are driven by an offset chain or belt drive.

The materials of construction would normally be mild steel both for the casing and the screw. End bearings are flange mounted ball type with intermediate bearings being plain phosphor bronze bushings.

Casings are totally enclosed with bolted and sealed covers. Where leaks occur, maintenance systems are in place to rectify.

Ignition hazard assessment			
Potential ignition source			**Measures applied to prevent the source becoming effective**
Normal Operation	**Expected malfunction**	**Rare malfunction**	
Screw and casing			Not a source of ignition. No contact between screw flights and casing. End bearings and intermediate hanger bearings are grease lubricated.
	Gradual failure of casing through abrasion with product leading to eventual leakage of product.		Not a source of ignition.
		Gudgeon pin or shaft failure at screw end or intermediate shaft leading to loss of conveying effect. In extreme cases this can lead to severe out of balance running resulting in failure of casing.	Zone 20 Applications will necessitate a rotation sensor to be installed on the non drive end of the shaft. For other applications this device is not seen as being safety critical but is seen as being good practice. Not expected to be an ignition source due to low power input and moderate relative velocity between moving parts (reference HSE paper). Any zone 20 applications must be assessed in detail on an

			individual basis.
End and intermediate hanger bearings			Not a source of ignition. End bearings and intermediate hanger bearings are grease lubricated.
	Bearing wear. Leading to increased noise and vibration		Not a source of ignition. Regular inspection and maintenance activities will indicate problem leading to bearing replacement.
		Hanger bearing collapse leading to frictional heating between screw and casing components.	Not expected to be an ignition source due to low power input and moderate relative velocity between moving parts (reference HSE paper). Any zone 20 applications must be assessed in detail on an individual basis.
Process conditions			Not an ignition source
	Down stream blockage of product flow leading to choke of product within casing. Frictional heating can lead to localised heating effect which could be a source of ignition within the choked product. At this point, product flow has stopped and therefore propagation of ignition source is not reasonable foreseeable.		Not an immediate ignition source. Drive motors are fitted with overload devices which will stop the machine under choked conditions
		Down stream blockage of product flow leading to choke of product within casing. Frictional heating can lead to localised heating effect which could be a source of ignition within the choked product. This combination with motor overload failure could lead to a credible source of ignition.	For zone 20 applications, conveyors must be fitted with a choke switch which must be considered safety critical.
Drive system (gear box, and belt or chain drive). External to casing.			Not an ignition source. Gearbox is oil lubricated and chain and drive belts are correctly tensioned.

	Gear box wear leading to increased noise and vibration.		Not an ignition source. Conveyors are inspected regularly. Increased noise and vibration will lead to replacement/repair.
		Gear box loss of lubrication leading to overheating.	Not a credible ignition source. It is not reasonably foreseeable that temperature will approach the ignition temperature. Excessive noise and vibration will lead to corrective action.
	Drive belt slippage due to incorrect tensioning leading to frictional heating. Most likely outcome is the eventual failure of the belt through wear.		Not likely to be an ignition source. Temperature will not reach ignition temperature of product. Regular inspection and loss of conveying function will quickly lead to repair.
	Chain drive failure due to broken link. Leading to loss of conveying effect.		No source of ignition.
		Drive belt total failure. Results in total lack of conveying action leading to a probable choke of material upstream.	Not an ignition source.
Motor			No external ignition source.
	Locked rotor condition caused by product choke		Not an immediate ignition source. Drive motors are fitted with overload devices which will stop the machine under choked conditions
		Locked rotor conditions caused by gudgeon pin failure or hanger bearing collapse. This in combination with motor overload failure could lead to a credible source of ignition.	No motors will be allowed in zone 20 applications
Overall ignition risk for this device has been assessed as **LOW**.			
Key controls needed to meet overall risk rating:- A. Zone 22 and 21:- • Maintenance • Motor overloads B. Zone 20 - as for 22 and 21 plus:- • Shaft rotation sensor • Choke switch			

2. Drag link type conveyors and elevayors

These conveyors generally handle barley and malt products, which may give rise to an internal zone 22 area. When handling steeped barley or green malt this will be a safe internal zone. In general the area outside the casing is not defined as a hazardous area.

These machines are usually driven by general purpose industrial electric motors. In most applications, the machine is driven through a gear box but some machines are driven by an offset chain or belt drive.

The materials of construction would normally be mild steel both for the casing and the chain and flights. End shaft bearings are flange mounted ball type. These bearings are located externally.

Casings are totally enclosed with bolted and sealed covers. Where leaks occur, maintenance systems are in place to rectify.

Ignition hazard assessment			
Potential ignition source			**Measures applied to prevent the source becoming effective**
Normal Operation	**Expected malfunction**	**Rare malfunction**	
Chain flights and casing			Not a source of ignition. Speed of machine is between $0.3ms^{-1}$ and $0.6ms^{-1}$ No frictional heat generated. End bearings are grease lubricated.
	Gradual failure of casing through abrasion leading to eventual leakage of product.		Not a source of ignition
		Chain breakage / link pin failure. Leading to loss of conveying effect and chain becoming jammed in drive end.	Due to slow speed this will not generate an ignition source. Motors are fitted with overload devices which will trip the machine under jammed conditions.
End bearings			Not a source of ignition. End bearings are grease lubricated.
	Bearing wear leading to increased noise and vibration.		Not a source of ignition. Regular inspection and maintenance activities will indicate problem leading to bearing replacement.
		Bearing collapse will lead to jammed chain.	Due to slow speed this will not generate an ignition source. Motors are fitted with overload devices which will trip the machine under jammed conditions.

Process conditions			Not an ignition source
	Down stream blockage of product flow leading eventually to choke of product within casing.		Not an ignition source. Due to nature and speed of machine frictional heating will not occur. Motors are fitted with overload devices which will trip the machine under choked conditions.
		Down stream blockage of product flow leading eventually to choke of product within casing. This in combination with the failure of the motor overloads would lead to the eventual burn out of motor.	No ignition source within casing of machine.
Drive system (gear box, and belt or chain drive). External to casing.			Not an ignition source. Gearbox is oil lubricated and chain and drive belts are correctly tensioned.
	Gear box wear leading to increased noise and vibration.		Not an ignition source. Conveyors are inspected regularly. Increased noise and vibration will lead to replacement/repair.
		Gear box loss of lubrication leading to overheating.	Not a credible ignition source. It is not reasonably foreseeable that temperature will approach the ignition temperature. Excessive noise and vibration will lead to corrective action.
	Drive belt slippage due to incorrect tensioning leading to frictional heating. Most likely outcome is the eventual failure of the belt through wear.		Not likely to be an ignition source. Temperature will not reach ignition temperature of product. Regular inspection and loss of conveying function will quickly lead to repair.
	Chain drive failure due to broken link, leading to loss of conveying effect.		No source of ignition.
		Drive belt total failure. Results in total lack of conveying action leading to a probable choke of material upstream.	Not an ignition source.

Motor			No external ignition source.
	Locked rotor condition caused by product choke		Not an immediate ignition source. Drive motors are fitted with overload devices which will stop the machine under choked conditions
		Locked rotor conditions caused by Chain breakage / link pin failure. This in combination with motor overload failure could lead to a credible source of ignition.	No motors will be allowed in zone 20 applications
Overall ignition risk for this device has been assessed as **LOW**.			
Key controls needed to meet overall risk rating:- • Maintenance • Motor overloads			

3. Belt and Bucket Elevators

These elevators generally handle malt, barley, fines and malt grist giving rise to internal zones of 22, 21 or 20. When handling steeped grain or green malt the internal zone is classified as safe. In general the area outside the casing is not defined as a hazardous area.

These machines are usually driven by general purpose industrial electric motors. In most applications, the machine is driven through a gear box but some machines are driven by an offset chain or belt drive.

The materials of construction would normally be mild steel both for the casing and the buckets. End shaft bearings are flange mounted ball type. These bearings are located externally. Belts tend to be of a rubber and textile construction.

Casings are totally enclosed with bolted and sealed covers. Where leaks occur, maintenance systems are in place to rectify.

Specific guidance on the use of these machines is given in NFPA 61 chapter 7.4. This would suggest that belt alignment sensors and bearing temperature and vibration monitoring devices are not safety critical for applications under $106m^3hr^{-1}$ or with belt speeds under $2.5ms^{-1}$.

Ignition hazard assessment			
Potential ignition source			**Measures applied to prevent the source becoming effective**
Normal Operation	**Expected malfunction**	**Rare malfunction**	
Belt/buckets and casing.			Not an ignition source. No contact between moving parts and casing.
	Slipping of belt at the driven pulley. This would lead to frictional heating. Could eventually lead to failure of belt.		Slippage will lead to heat generation but it is very unlikely to generate sufficient heat to ignite cloud or layer. All belt and bucket elevators will be fitted with rotation sensors (NFPA guidance) which will trip the machine if slippage is detected. Maintenance inspections will include belt tension checks.
	Belt moves out of alignment. This could lead to frictional heating or impact between buckets and casing.		May lead to an ignition source. All new elevators will be fitted with a self centering drive pulley. All machines will require a preventative maintenance schedule.
		Self centering drive	It is the industry's view that

		pulley fails leading to frictional heat or impact between buckets and casing	these machines should be fitted with explosion relief as a mitigation measure as this is recognised in the guidance as being the appropriate measure to take (reference HSG 103).
Drive and idler shaft bearings			Not a source of ignition. Bearings are grease lubricated.
	Bearing wear leading to increased noise and vibration.		Not a source of ignition. Regular inspection and maintenance activities will indicate problem leading to bearing replacement.
		Bearing collapse will lead to belt misalignment leading to frictional heating.	See belt alignment above.
Process conditions			Not an ignition source
	Down stream blockage of product flow leading eventually to choke of product within the boot leading to belt slippage.		May form an ignition source. Motors are fitted with overload devices which will trip the machine under choked or increased load conditions. All machines for zone 21 applications will be fitted with rotations sensors which will trip the machine.
		Down stream blockage of product flow leading eventually to choke of product within boot. This in combination with the failure of the motor overloads and rotation sensor will lead to frictional heating.	May form an ignition source. All zone 20 application elevators will be fitted with choke switches on outlet to trip the machine.
Drive system (gear box, and belt or chain drive). External to casing.			Not an ignition source. Gearbox is oil lubricated and chain and drive belts are correctly tensioned.
	Gear box wear leading to increased noise and vibration.		Not an ignition source. Conveyors are inspected regularly. Increased noise and vibration will lead to replacement/repair.

		Gear box loss of lubrication leading to overheating.	Not a credible ignition source. It is not reasonably foreseeable that temperature will approach the ignition temperature. Excessive noise and vibration will lead to corrective action.
	Drive belt slippage due to incorrect tensioning leading to frictional heating. Most likely outcome is the eventual failure of the belt through wear.		Not likely to be an ignition source. Temperature will not reach ignition temperature of product. Regular inspection and loss of conveying function will quickly lead to repair.
	Chain drive failure due to broken link. Leading to loss of conveying effect.		No source of ignition.
		Drive belt total failure. Results in total lack of conveying action leading to a probable choke of material upstream.	Not an ignition source.
Motor			No external ignition source.
	Locked rotor condition caused by product choke		Not an immediate ignition source. Drive motors are fitted with overload devices which will stop the machine under choked conditions
		Locked rotor conditions caused by product choke in combination with motor overload failure could lead to a credible source of ignition.	No motors will be allowed in zone 20 applications
Overall ignition Risk for this device has been assessed as **MEDIUM**. With the provision of explosion relief, the overall risk has been assessed as **LOW**			

Key controls needed to meet overall risk rating:-

Zone 22 applications:-

- Maintenance - these machines must be part of a planned preventative maintenance schedule.
- Motor overloads
- Self centering drive pulley

Zone 21 applications - zone 22 plus:-

- Rotation sensors

Zone 20 applications - zone 21 plus:-

- Choke switches on outlet

4. Destoner

Destoners are used to separate stones and other heavier than grain foreign material from the process.

These machines function by floating the lighter grain on a bed of air whilst heavier foreign bodies remain on the wire mesh moving deck of the machine and are vibrated in the opposite direction to the flow of malt.

Their operation is dependent on a large flow of air supplied by a dedicated fines collection unit.

They can be seen as a control measure to help prevent ignition sources in the process.

Due to the low power and speed of these machines (typically fractional kW), they are unlikely to be a mechanical source of ignition (reference HSE paper)

Ignition hazard assessment			
Potential ignition source			**Measures applied to prevent the source becoming effective**
Normal Operation	**Expected malfunction**	**Rare malfunction**	
Normal operation of moving deck.			Not an ignition source.
	Bearing and bush wear in vibrating bed mechanism. Will lead to increased noise and vibration. Outside product flow.		Not an ignition source
		Bearing or bush failure leading to loss of shaker motion. This would to lead to loss of destoning effect.	Not an ignition source
Normal Process conditions			Not an ignition source
	Choke of product down stream will lead to spill of whole grains at discharge point of machine. Machine action will not produce frictional heating or other ignition source.		Not an ignition source
		Loss of air. Will lead to loss of destoning effect. Motor trip of air system will lead to shutdown of grain handling sequence including the destoner.	Not an ignition source. Undesirable condition which should be rectified as soon as possible.

Belt driving eccentric rod – normal operation. External to machine body.			Not an ignition source. Drive belts are correctly tensioned.
	Drive belt slippage due to incorrect tensioning leading to frictional heating. Most likely outcome is the eventual failure of the belt through wear.		Not likely to be an ignition source. Temperature will not reach ignition temperature of product. Regular inspection and loss of destoning function will quickly lead to repair.
		Drive belt total failure. Results in total lack of destoning action. Product flow will continue through machine.	Not an ignition source.
Motor bearing			Not a source of ignition
	Bearing wear leading to increased noise and vibration.		More difficult to detect during regular inspections and maintenance due to functioning of machine. For this reason, no destoner motors will be located in a zone 21 area.
		Eventual bearing collapse.	No destoner motors will be located in a zone 20 area.
Overall ignition risk for this device has been assessed as **LOW**.			
Key controls needed to meet overall risk rating:- • Maintenance • Restriction on location (must be located in safe or zone 22 area only)			

5. Flat bed dresser

Machine consists of a series of sieve boats (inclined screens), which separate under and over sized seeds, straw, chaff and fines. This would include an electric motor driving eccentric rod mechanism to vibrate these beds.

Typically these machines incorporate an internally mounted aspiration fan which is used to separate the lighter fractions. The drive motor is typically rated between 4 and 11kW. The fan is either driven directly from the motor or through belt drive.

Machines may contain integral screws or rotary valves used to discharge separated rejected product to bagging or collection points. This is small fraction of the overall product volume. The internal screw conveyors and/or rotary valves are very low power and very low speed and will not form a credible ignition source. They have not been assessed below.

Fines are removed from the top of the machine by external fines extraction system.

Ignition hazard assessment			
Potential ignition source			**Measures applied to prevent the source becoming effective**
Normal Operation	**Expected malfunction**	**Rare malfunction**	
Feed roller			No source of ignition
	Bearing wear leading to increased noise and vibration.		No source of ignition
		Bearing collapse would result in uneven feed to machine. Feed roller may jam leading to inlet choke.	Roller is fractional kW and is slow moving. Will not create an ignition source.
Belt driving feed roller – normal operation. External to machine body.			Not an ignition source. Drive belts are correctly tensioned.
	Drive belt slippage due to incorrect tensioning leading to frictional heating. Most likely outcome is the eventual failure of the belt through wear.		Not likely to be an ignition source. Temperature will not reach ignition temperature of product. Regular inspection and loss of feed function will quickly lead to repair.
		Drive belt total failure. Results in total lack of feed to machine resulting in inlet choke.	Not an ignition source.
Sieve boats Normal operation			Not an ignition source.

	Bearing and bushing wear in sieve boats shaker mechanism. Will lead to increased noise and vibration.		Not an ignition source
		Bearing or bushing failure leading to loss of shaker motion. This would to loss of cleaning effect and leading to product choke.	Not an ignition source
	Shaker rod malfunction leading to loss of operation and product choke.		Not an ignition source.
Shaker mechanism drive motor			No external ignition source.
	Locked rotor condition caused by product choke.		Not an immediate ignition source. Drive motors are fitted with overload devices which will stop the machine under choked conditions
		Locked rotor conditions caused by product choke in combination with motor overload failure could lead to a credible source of ignition.	No motors will be allowed in zone 20 applications unless at category 1.
Internal aspiration fan			Not a source of ignition
	Bearing wear leading to increased noise and vibration.		Not a source of ignition. Regular inspection and maintenance activities will indicate problem leading to repair.
		Bearing collapse leading to impingement of fan on casing.	Likely to be source of ignition based on speed and power of machine. These machines will not be operated in a zone 20 location.
	Drive belt slippage due to incorrect tensioning leading to frictional heating. Most likely outcome is the eventual failure of the belt through wear.		Not likely to be an ignition source. Temperature will not reach ignition temperature of product. Regular inspection and loss of feed function will quickly lead to repair.

		Drive belt total failure. Results in lack of aspiration which result in loss of ability to remove lighter fractions.	Not an ignition source.
Normal Process conditions			Not an ignition source
	Choke of product down stream will lead to spill of whole grains at discharge point of machine. Machine action will not produce frictional heating or other ignition source.		Not an ignition source
		Loss of fines extraction air. Will lead to increased build up of light fraction within pre and post aspiration chambers. Likely that this material will be discharged with the trash.	Not an ignition source. Undesirable condition which should be rectified as soon as possible. Motor trip of air system will lead to shutdown of grain handling sequence.
Overall ignition risk for this device has been assessed as **LOW**.			
Key controls needed to meet overall risk rating:- • Maintenance • Motor overloads			

6. Rotary dresser

Simple devices installed to remove foreign objects larger or smaller than grain.

Typically consists of a drum sheathed in a mesh or perforated metal plate. Grain will fall through the mesh and larger objects will be rejected.

Typically these machines are low speed and low power (under 4kW).

Ignition hazard assessment			
Potential ignition source			**Measures applied to prevent the source becoming effective**
Normal Operation	**Expected malfunction**	**Rare malfunction**	
Drum rotation			No source of ignition
	Bearing wear leading to increased noise and vibration.		No source of ignition. Regular inspection and maintenance activities will indicate problem leading to repair.
		Bearing collapse will not lead to drum impinging on due to size of clearance.	Not an ignition source.
	Drive belt slippage due to incorrect tensioning leading to frictional heating. Most likely outcome is the eventual failure of the belt through wear.		Not likely to be an ignition source. Temperature will not reach ignition temperature of product. Low power and speed of machine will not generate sufficient heat to create credible ignition source. Regular inspection and loss of feed function will quickly lead to repair.
		Drive belt total failure. Results in loss of forward feed resulting in a product choke.	Not an ignition source. Motor overloads will trip machine in choked condition.
Normal Process conditions			Not an ignition source
	Choke of product down stream will lead to eventual choke of machine. Resulting in drive belt slippage and/or motor overload.		Not an ignition source. Motor overloads will trip machine in choke situation.

		Loss of fines extraction air.	Not an ignition source. Undesirable condition which should be rectified as soon as possible. Motor trip of air system will lead to shutdown of grain handling sequence.
Overall ignition risk for this device has been assessed as **LOW**.			
Key controls needed to meet overall risk rating:- • Maintenance • Motor overloads			

7. Rubble separator (e.g. Rotoclean)

This machine is used to initially clean the grain supplied by farms during the harvest.

It is an efficient and rugged rubble separator for high capacity cleaning of grains. The machines are usually located at the intake point of the plant.

The machine is totally enclosed, fines proof and generally fabricated from mild steel.

The cleaning process is affected by three rotary reels and an internal aspiration system which re-circulates 90% of the air. Fines and lighter particles are removed by the air system, associated mini cyclone and integral screw conveyor. The larger particles (straw, stones, etc) are removed from the barley by the rotary reels.

Typically, the rotary reel system is driven by a variable speed 1.5kW motor and the air fan by a 4 kW motor. The individual rotors and integral screw conveyor have fractional kW input power.

Ignition hazard assessment			
Potential ignition source			**Measures applied to prevent the source becoming effective**
Normal Operation	**Expected malfunction**	**Rare malfunction**	
Rotating reels			Not a source of ignition.
	Bearing wear leading to increased noise and vibration.		No source of ignition. Regular inspection and maintenance activities will indicate problem leading to repair.
		Bearing collapse leading to friction between reels and surrounding finger plates.	Due to low power and speed of reel relative to finger plates, this is not a credible ignition source.
Drive belt system (drive belts correctly tensioned).			Not an ignition source.
	Drive belt slippage due to incorrect tensioning leading to frictional heating. Most likely outcome is the eventual failure of the belt through wear.		Low power and speed of machine will not generate sufficient heat to create credible ignition source. Regular inspection and loss of feed function will quickly lead to repair.
		Drive belt total failure. Results in loss of cleaning effect and product flow.	Not an ignition source.

Aspiration fan (where fitted)			Not an ignition source.
	Bearing wear leading to increased noise and vibration.		Not an ignition source. Regular inspection and maintenance activities will indicate problem leading to repair
		Bearing collapse leading to fan striking casing and/or frictional heating.	Due to speed of rotation and power of fan, this is a likely ignition source. These bearings must be part of a planned maintenance schedule.
	Drive belt slippage due to incorrect tensioning leading to frictional heating. Most likely outcome is the eventual failure of the belt through wear.		Not a credible ignition source. Fines removal efficiency will be affected. Belt system located external to machine.
		Drive belt total failure. Results in loss of fines removal.	Not an ignition source.
Integral screw conveyor			Not an ignition source
	Bearing wear leading to increased noise and vibration		Not an ignition source. Regular inspection and maintenance activities will indicate problem leading to repair
		Bearing collapse leading to frictional heating between screw and casing.	Not expected to be an ignition source due to the low power and low relative speed between screw and casing.
Overall ignition risk for this device has been assessed as **LOW**.			
Key controls needed to meet overall risk rating:- • Maintenance • Motor overloads must be part of a planned preventative maintenance schedule.			

8. Fines collection and venting filter units

These units universally employ filter cloths or bags to filter out fines in suspension and exhaust clean air.

Fan unit is mounted on the clean air side of the device, drawing fines laden air from the process equipment through the filter cloth/bags and venting clean air to atmosphere.

Two methods are employed to dislodge fines from cloths/bags for collection and disposal. These are most commonly the use of a fractional kW shaker motor, or reverse air jet systems. Larger systems that run continuously utilise reverse jet air, which is applied periodically.

The fan unit can be integral to the machine or mounted remotely.

The venting filter units do not employ fans and rely on air displaced during bin filling for operation.

Shaker motors generally run for a short period after the completion of a milling or grain intake sequence (after a time delay to allow fan to stop).

The internals of the fan casing has been identified as being zone 22 to take account of the irregular failure of the filter cloths/bags.

Throughout industry, the general practice has been to provide explosion relief on such units as flammable clouds of fines are regularly present and it is not possible to eliminate ignition sources.

Under the COSHH regulations, these units are inspected by an independent third party inspection company on an annual basis. Measurements of fines extraction efficiency are made during the inspections.

Ignition hazard assessment			
Potential ignition source			**Measures applied to prevent the source becoming effective**
Normal Operation	**Expected malfunction**	**Rare malfunction**	
Fan operation			Not a source of ignition.
	Bearing wear leading to increased noise and vibration.		Not a source of ignition. Regular inspection and maintenance activities will indicate problem leading to repair.
		Bearing collapse leading to impingement of fan on casing.	Likely to be source of ignition based on speed and power of machine. These machines will not be operated in a zone 20 location.

Normal operation of shaker mechanism and drive.			Not an ignition source.
	Bearing and bushing wear in shaker mechanism. Will lead to increased noise and vibration.		Not an ignition source. Will not create enough heat to form a credible ignition source as shaker is fractional kW and runs for maximum of 5 minutes in a 6 hour period
		Bearing or bushing failure leading to loss of shaker motion. Filter cloths/bags would blind leading to a loss of fines extraction efficiency.	Not an ignition source. Undesirable event and must be rectified as a priority. Most units are fitted with differential pressure gauges to detect filter blinding.
Cyclone			
No moving parts. Low risk under normal operation.			Not an ignition source
Fan and shaker motors – normal operation.			Not a source of ignition
	Locked rotor condition caused by mechanism failure		Not an immediate ignition source. Drive motors are fitted with overload devices which will stop the machine under choked conditions
		Locked rotor conditions in combination with motor overload failure could lead to a credible source of ignition.	No motors will be allowed in zone 20 applications
Overall ignition risk for this device has been assessed as **LOW**.			
Key controls needed to meet overall risk rating:- • Maintenance • Motor overloads			

9. Roller Mill (used only where the site produces grist.)

These machines are, by the nature of their operation, robustly constructed from cast aluminium or cast steel.

Due to the speed of rotation (800rpm), and the energy input (typically 3kW to 11kW); these machines present a higher inherent risk.

These machines are recognised as being a mechanical source of ignition. Actual explosions within are however still rare.

Although magnets and grain dressing are employed, the removal of all tramp metal and other foreign objects can not be guaranteed.

Ignition hazard assessment			
Potential ignition source			**Measures applied to prevent the source becoming effective**
Normal Operation	**Expected malfunction**	**Rare malfunction**	
Feed roller			Not a source of ignition. All bearings are grease lubricated.
	Bearing wear leading to increased noise and vibration.		Not a source of ignition. Regular inspection and maintenance activities will indicate problem leading to repair. Mill bearing must be part of a planned maintenance system.
		Bearing collapse leading to impingement of roller on casing.	Likely to be source of ignition based on speed and power of machine. Feed roller operates in zone 22 and therefore operation is acceptable.
Main rollers			Not a source of ignition. All bearings are grease lubricated
	Bearing wear leading to increased noise and vibration.		Not a source of ignition. Regular inspection and maintenance activities will indicate problem leading to repair. Mill bearings must be part of a planned maintenance system.
		Bearing collapse leading to impingement of roller on casing.	Likely to be source of ignition based on speed and power of machine.
Foreign bodies and tramp metal in process material.			In normal operation, the tramp metal and other foreign bodies do not result in a credible ignition source

	Credible ignition source resulting from tramp metal and other foreign bodies.		This cannot be prevented with absolute certainty. Mills must be protected by efficient magnets.
		N/A	
Overall ignition Risk for this device has been assessed as **MEDIUM**			
Key controls needed to meet overall risk rating:- • Maintenance • Magnets mounted upstream of mill • Motor overloads • Roller bearings must be part of a specific preventive maintenance schedule			

10. Hammer Mill

Machine has limited moving parts and consists of a main rotor and associated hammers and a slotted metal sieve plate stator.

Rotor is direct driven from electric motor and is high speed (typically 1500rpm). Rotor tip speed is in the order of 100ms^{-1}.

As with roller mills these machines are robustly constructed. They are also recognised as a source of ignition.

Although magnets and grain dressing are employed, the removal of all tramp metal and other foreign objects can not be guaranteed.

Ignition hazard assessment			
Potential ignition source			**Measures applied to prevent the source becoming effective**
Normal Operation	**Expected malfunction**	**Rare malfunction**	
Main rotor			Not a source of ignition. All bearings are grease lubricated.
	Bearing wear leading to increased noise and vibration.		Not a source of ignition. Regular inspection and maintenance activities will indicate problem leading to repair. Mill bearing must be part of a planned maintenance system.
		Bearing collapse leading to impingement of rotor and hammers on casing.	Likely to be source of ignition based on speed and power of machine.
Drive Coupling			Not a source of ignition
	Coupling failure leading to loss of milling action and loss of forward feed of product.		Not a source of ignition
		N/A	
Foreign bodies and tramp metal in process material.			In normal operation, the tramp metal and other foreign bodies do not result in a credible ignition source
	Credible ignition source resulting from tramp metal and other foreign bodies.		This cannot be prevented with absolute certainty. Mills must be protected by efficient magnets.
		N/A	

Overall ignition Risk for this device has been assessed as **MEDIUM**
Key controls needed to meet overall risk rating:- • Maintenance • Magnets mounted upstream of mill • Motor overloads • Rotor bearings must be part of a specific preventive maintenance schedule

11. Conditioning screw (Turbo-mix)

These units generally mix fines and malt culms and condition with water prior to pellet mill.

Conditionings are typically 5-7.5kW with screw tip speed of approx. $5ms^{-1}$.

Generally these machines have an internal zone 21 area. In general the area outside the casing is not defined as a hazardous area.

These machines are usually driven by general purpose industrial electric motors. In most applications, the machine is driven through a gear box but some machines are driven by an offset chain or belt drive.

The materials of construction would normally be mild steel both for the casing and the screw. End bearings are flange mounted ball type.

Casings are totally enclosed with bolted and sealed covers. Where leaks occur, maintenance systems are in place to rectify.

Ignition hazard assessment			
Potential ignition source			**Measures applied to prevent the source becoming effective**
Normal Operation	**Expected malfunction**	**Rare malfunction**	
Screw and casing			Not a source of ignition. No contact between screw flights and casing. End bearings and intermediate hanger bearings are grease lubricated.
	Gradual failure of casing through abrasion with product leading to eventual leakage of product.		Not a source of ignition.
		Gudgeon pin or shaft failure at screw drive end leading to loss of conveying effect. Pin or shaft failure at non drive end can lead to severe out of balance running resulting in failure of casing.	A rotation sensor installed on the non drive end of the shaft. is seen as being good practice but not safety critical as the internals are zone 21. This machinery must be subject to a planned maintenance schedule.
End bearings			Not a source of ignition. End bearings and intermediate hanger bearings are grease lubricated.

	Bearing wear. Leading to increased noise and vibration		Not a source of ignition. Regular inspection and maintenance activities will indicate problem leading to bearing replacement.
		Bearing collapse leading to frictional heating between shaft and bearing housing (impingement on casing not feasible due to clearance gap between screw flights and casing).	Not a credible source of ignition as relative velocity between shaft and housing will be less than $1ms^{-1}$ (typically $0.5ms^{-1}$)
Process conditions			Not a ignition source
	Down stream blockage of product flow leading to choke of product within casing. Due to construction of flights, frictional heating is highly unlikely to lead to a credible source of ignition within the choked product.		Not an immediate ignition source. Drive motors are fitted with overload devices which will stop the machine under choked conditions
		N/A	
Drive system (gear box, and belt or chain drive). External to casing.			Not an ignition source. Gearbox is oil lubricated and chain and drive belts are correctly tensioned.
	Gear box wear leading to increased noise and vibration.		Not an ignition source. Conveyors are inspected regularly. Increased noise and vibration will lead to replacement/repair.
		Gear box loss of lubrication leading to overheating.	Not a credible ignition source. It is not reasonably foreseeable that temperature will approach the ignition temperature. Excessive noise and vibration will lead to corrective action.
	Drive belt slippage due to incorrect tensioning leading to frictional heating. Most likely outcome is the eventual failure of the belt through wear.		Not likely to be an ignition source. Temperature will not reach ignition temperature of product. Regular inspection and loss of conveying function will quickly lead to repair.

	Chain drive failure due to broken link. Leading to loss of conveying effect.		No source of ignition.
		Drive belt total failure. Results in total lack of conveying action leading to a probable choke of material upstream.	Not an ignition source.
Motor			No external ignition source.
	Locked rotor condition caused by product choke		Not an immediate ignition source. Drive motors are fitted with overload devices which will stop the machine under choked conditions
		Locked rotor conditions caused by gudgeon pin failure. This in combination with motor overload failure could lead to a credible source of ignition.	No motors will be allowed in zone 20 applications
Overall ignition risk for this device has been assessed as **LOW**.			
Key controls needed to meet overall risk rating:- • Maintenance • Motor overloads • Shaft arrangement must be part of a planned maintenance schedule.			

12. Rotary Valve

These devices are used for three main functions:- for flow regulation from bins; as an air lock in fines collection and vacuum cleaning systems; as an explosion choke.

These machines can be direct driven through a gear box, or belt or chain driven. They are slow rotating devices with a rotor tip speed of typically $0.5ms^{-1}$. The drive is typically fractional kW rated.

They are of robust construction.

Ignition hazard assessment			
Potential ignition source			**Measures applied to prevent the source becoming effective**
Normal Operation	**Expected malfunction**	**Rare malfunction**	
Rotor normal function			Not a source of ignition.
	Bearing wear leading to increased noise and vibration.		Not a source of ignition. Regular inspection and maintenance activities will indicate problem leading to repair.
		Bearing collapse leading to frictional heating between rotor and casing.	Frictional heating in this case will not lead to a credible source of ignition due to slow speed and low input power.
Process conditions			Not a source of ignition
	Down stream choke of product leading to rotor filling up and not discharging.		Some frictional heating is foreseeable however due to low speed and power this will not be a credible source of ignition.
		Foreign object in product flow leading to jammed rotor	Will not generate sparks and motors are fitted with overload devices to trip machine in locked rotor conditions. Not a credible source of ignition.
Overall ignition risk for this device has been assessed as **LOW**.			
Key controls needed to meet overall risk rating:- • Maintenance • Motor overload • Where used as explosion choke or in a zone 20 application, device must be subject to regular maintenance inspection with particular regard to maintaining rotor to casing gap.			

13. Pellet Mill

Pellet mills for maltings applications are used to compress a mixture of fines and malt culms into an animal feeds pellet.

This requires large inputs of mechanical energy. typically employing a 70 to 200kW electric motor. Machine operates at high speed and can be directly driven or via V belt pulley arrangement. The mill contains an internal gearing arrangement that is not exposed to product.

Machine works by forcing product through a non-rotating die using rotating roller assemblies. These rollers incorporate integral roller bearings that rely on grease lubrication.

The machine runs hot in normal operation leading to the need to cool the produced pellets.

Ignition hazard assessment			
Potential ignition source			**Measures applied to prevent the source becoming effective**
Normal Operation	**Expected malfunction**	**Rare malfunction**	
Roller operation normal			Not a source of ignition.
	Roller bearing wear leading to increased noise and vibration.		Not an ignition source. Auto lubrication or lubrication schedule is critical to the management of the bearings and must be adhered to. This machine must be part of a planned maintenance schedule.
		Bearing collapse leading to high frictional heating.	Credible source of ignition due to high speed and energy of machine. Heat detection on the casing and/or lubrication system of the machine is safety critical.
Overall ignition risk for this device has been assessed as **Medium**.			
Key controls needed to meet overall risk rating:- • Motor overloads • Maintenance/lubrication schedule for the roller bearings is critical. This machine must be part of a planned maintenance schedule. • Heat detection on machine casing and/or lubrication system to prevent bearing collapse.			

14. Barley Drier

Grain is dried to stabilise raw grain for storage prior to malting.
Two types in general use:

1) The vertical tower design, where the grain moves down through the tower by gravity, whilst hot air passes up through it,
2) A moving bed design, on which the grain is conveyed through the hot air drying area.

Ignition hazard assessment			
Potential ignition source			**Measures applied to prevent the source becoming effective**
Normal Operation	**Expected malfunction**	**Rare malfunction**	
Fan operation			Not a source of ignition.
	Bearing wear leading to increased noise and vibration.		Not a source of ignition. Regular inspection and maintenance activities will indicate problem leading to repair.
		Bearing collapse leading to impingement of fan on casing.	Likely to be source of ignition based on speed and power of machine. These machines will not be operated in a zone 20 location.
Discharge control (feed gates, rotory valve)			No source of ignition
	Valves jam		No source of ignition. Rotational speed is low.
Motor (moving beds)			No source of ignition
	Locked rotor condition caused by product choke		No source of ignition. Drive motors are fitted with overload devices which will stop the machine under choked conditions
Bearings			Not a source of ignition.
	Bearing wear. Leading to increased noise and vibration		Not a source of ignition. Regular inspection and maintenance activities will indicate problem leading to bearing replacement.
		Bearing collapse leading to frictional heating between shaft and bearing housing	Not a credible source of ignition as relative velocity between shaft and housing will be less than $1ms^{-1}$ (typically $0.5ms^{-1}$)

<table>
<tr><td>Burner</td><td></td><td></td><td>Source of ignition. Full safety interlocking devices.</td></tr>
<tr><td></td><td>Flame failure</td><td></td><td>No source of ignition.</td></tr>
<tr><td></td><td></td><td>Safety devices</td><td>Multiple levels of safety devices. Failure back-up.</td></tr>
<tr><td colspan="4">Overall ignition risk for this device has been assessed as .Medium</td></tr>
<tr><td colspan="4">Key controls needed to meet overall risk rating:-
• Maintenance
• Motor overloads
• Fuel cut off on flame failure
• Temperature controls and settings
• Housekeeping of drier internals</td></tr>
</table>

SECTION 4

THE MAGB FULL SUPPORT DOCUMENTATION CONCERNING THE REQUIREMENTS TO BE MET BY MALTINGS UNDER THE DANGEROUS SUBSTANCES AND EXPLOSIVE ATMOSPHERES REGULATIONS 2002

SECTION FOUR of this report and the work it describes were reviewed and edited by the Health and Safety Laboratory under contract to the Maltsters Association of Great Britain. Its contents, including any opinions and/or conclusions expressed or recommendations made, do not necessarily reflect policy or views of the Health and Safety Executive

Some background to the MAGB's work on dust explosion prevention in maltings.

The subject of dust explosions in maltings has always been taken very seriously by UK Maltsters, which is reflected by the extremely low number of such events, which have never been of a serious nature, or resulting in loss of life. This has not been the case in other parts of the world; in Metz, France in 1982 twelve people were killed by this hazard.

In Blaye, France in 1997 eleven people were killed as a result of a dust explosion.

1. INTRODUCTION to SECTION 4

Maltsters and dust explosion control.
Maltsters have been dealing with the prevention of dust explosion risks now for many years, and have worked closely with the Health and Safety Executive to ensure the safety of their plant and people on their sites.

However EU and subsequent UK compliance legislation have now formalized how such precautionary actions should be taken and maltsters must ensure that they are fully in compliance by July 2006 for all existing malting sites.

Background to the Legislation changes.
The origins of the current changes are embedded in Article 137 of the Treaty establishing the EU, namely that the Council of the EU ***"may adopt, by means of Directives, minimum requirements for encouraging improvements, especially in the working environment, to guarantee a better level of protection of the health and safety of workers"***

In March 1994 an EU Directive was approved under that empowerment, to deal with the equipment and protective systems intended for use in potentially explosive atmospheres. This was **Directive 94/9/EC, sometimes called "The ATEX Equipment Directive".**

In December 1999 an EU Directive to deal with the minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres entered into EU law. This was **Directive 1999/92/EC, sometimes called "The ATEX Workplace Directive."**

To bring both these Directives into UK law compliance, Statutory Instrument 1996/192, amended by S.I. 2001/3766 covered the requirements of the ATEX Equipment Directive, and **Statutory Instrument 220 N0. 2776, The Dangerous Substances & Explosive Atmospheres Regulations (DSEAR)**, which came into force in December 2002, dealt with the requirements of The ATEX Workplace Directive.

The DSEAR legislation covers all the requirements of 1999/92/EC Directive, as well as hazards associated with substances whose chemical properties can result in risk, and thus fall under the requirements of European Chemical Agents Directive 98/24/EC.

DSEAR will be enforced by:
The HSE or local authorities depending on the allocation of premises under the Health and Safety (Enforcing Authority) Regulations 1998, and the Fire authorities at most premises subject to DSEAR in relation to general fire precautions such as means of escape.

2. WHAT DO MALTSTERS HAVE TO DO TO COMPLY WITH DSEAR?

Every time grain or malt is moved, the abrasion produces dust, which at certain levels of concentration in air can produce an explosive mixture, which can be ignited by a spark or naked flame, so the malting industry falls within the remit of DSEAR and hence ATEX regulations.

This means that for each malting site the following requirements MUST be met:

- **A) A risk assessment of any work activities involving dangerous substances must be carried out and recorded (if you have more than 5 employees) in a DSEAR Risk Assessment document. (Reg. 5).**
- **B) Areas where potential explosion risks exist must be identified, and they must be classified into zones as laid down in DSEAR. These Zones should be clearly marked where necessary. This should be carried out after implementing measures to reduce risks. (Reg. 7).**
- **C) The Company must provide measures to eliminate or reduce risks identified in the assessment as far as is reasonably practicable, and provide suitable personal protective equipment (PPE) where necessary. (Reg. 6).**
- **D) Adequate information and training must be provided to employees relative to potential fire and explosion prevention. (Reg. 9).**
- **E) Procedures and equipment to deal with accidents and emergencies must be provided. (Reg. 8).**
- **F) Provision must be made for the identification of hazardous contents of containers and pipes. (Reg. 10).**
- **G) Where there is more than one employer at a workplace, then the measures taken under DSEAR must be co-ordinated between the employers and the 'aim of co-ordination' recorded in the risk assessment. (Reg. 11).**

Much of this work should have already been done under existing requirements to manage fire and explosion risks as required by **the Management of Health and Safety at Work Regulations 1999 (The Management Regulations.),** but it expands those requirements in the following areas:

- (i) The requirement of a competent person to carry out the risk assessment of potential explosive atmospheres locations at each malting site. It does not necessarily call for this to be done by external consultants. However, if you are not competent to do it, then you must use someone who is.
- **(ii)** Existing documentation on training and emergency actions may not address all the relevant issues required under DSEAR, so it may require more comprehensive documentation in some areas than that previously existing.
- **(iii)** Relevant site signposting in relation to zones with dust explosion risk will be required.

2.1 Time-Table

The risk assessment should have been carried out by July 2003 unless a detailed assessment has already been carried out of the risks from fire and explosion under the Management Regulations 1999. Measures identified as necessary by the risk assessment have to be put into place promptly and full compliance on having all necessary changes to reduce explosion risks must be completed for existing maltings plant by July 2006.

Any new equipment must be compliant after July 2003.

3. THE EXPLOSION PREVENTION RISK ASSESSMENT.

DSEAR specifies that the site be properly assessed for potential explosion risks and that a specification must be drawn up for a safe work situation, based on the likelihood of identified hazards occurring.

The requirements of Regulation 5 from DSEAR are shown as:

(1) Where a dangerous substance is or is liable to be present at the workplace, the employer shall make a suitable and sufficient assessment of the risks to his employees which arise from that substance.

(2) The risk assessment shall include consideration of -

> ***(a) the hazardous properties of the substance;***
> ***(b) information on safety provided by the supplier, including information contained in any relevant safety data sheet;***
> ***(c) the circumstances of the work including -***
>> ***(i) the work process and substances used and their possible interactions;***
>> ***(ii) the amount of the substance involved;***
>> ***(iii) where the work will involve more than one dangerous substance, the risk presented by such substances in combination;***
>> ***and***
>> ***(iv) the arrangements for the safe handling, storage and transport of dangerous substances and of waste containing dangerous substances;***
>
> ***(d) activities, such as maintenance, where there is the potential for a high level of risk;***
> ***(e) the effect of measures which have been or will be taken pursuant to these Regulations;***
> ***(f) the likelihood that an explosive atmosphere will occur and its persistence;***
> ***(g) the likelihood that ignition sources, including electrostatic discharges, will be present and become active and effective;***
> ***(h) the scale of the anticipated effects of a fire or an explosion;***
> ***(i) any places which are or can be connected via openings to places in which explosive atmospheres may occur;***
> ***and***
> ***(j) such additional safety information as the employer may need in order to complete the risk assessment.***

(3) The risk assessment shall be reviewed by the employer regularly so as to keep it up to date and particularly if -

> ***(a) there is reason to suspect that the risk assessment is no longer valid;***
> ***or***
> ***(b) there has been a significant change in the matters to which the risk assessment relates including when the workplace, work processes, or organisation of the work undergoes significant changes, extensions or conversions; and where, as a result of the review, changes to the risk assessment are required, those changes shall be made.***

(4) Where the employer employs five or more employees, the employer shall record the significant findings of the risk assessment as soon as is practicable after that assessment is made, including in particular -

> ***(a) the measures which have been or will be taken by him pursuant to these Regulations;***
> ***(b) sufficient information to show that the workplace and work processes are designed, operated and maintained with due regard for safety and that, in accordance with the Provision and Use of Work Equipment Regulations 1998, adequate arrangements have been made for the safe use of work equipment; and***
> ***(c) where an explosive atmosphere may occur at the workplace and subject to the transitional provisions in regulation 17(1) to (3), sufficient information to show:***
>> ***(i) those places which have been classified into zones pursuant to regulation 7(1);***
>> ***(ii) equipment which is required for, or helps to ensure, the safe operation of equipment located in places classified as hazardous pursuant to regulation 7(1);***
>> ***(iii) that any verification of overall explosion safety required by regulation 7(4) has been carried out; and***
>> ***(iv) the aim of any co-ordination required by regulation 11 and the measures and procedures for implementing it.***

(5) No new work activity involving dangerous substances shall commence unless;
> ***(a) an assessment has been made and***
> ***(b) the measures required by these regulations have been implemented.***

Note, in connection with Regulation 5 point (4) for the risk assessed explosion prevention report, that the HSE have indicated that the documentation will be valuable in convincing HSE Inspectors that the requirements of DSEAR have been met.

When the assessment identifies a potential risk then the Company has to take action to ensure that it either eliminated, or if that is not possible then it must be reduced so far as is reasonably practical. Regulation 6 gives guidance on how this can be best achieved, reading from point 6 paragraph (4):

(4) The following measures are, in order of priority, those specified for the purposes of paragraph (3)(a)-
> ***(a) the reduction of the quantity of dangerous substances to a minimum;***
> ***(b) the avoidance or minimising of the release of a dangerous substances;***
> ***(c) the control of the release of a dangerous substance at source;***
> ***(d) the prevention of the formation of an explosive atmosphere, including the application of appropriate ventilation;***
> ***(e) ensuring that any release of a dangerous substance which may give rise to risk is suitably collected, safely contained, removed to a safe place, or otherwise rendered safe, as appropriate;***
>
> ***(f) the avoidance of -***
>> ***(i) ignition sources including electrostatic discharges; and***
>> ***(ii) adverse conditions which could cause dangerous substances to give rise to harmful physical effects; and***
>
> ***(g) the segregation of incompatible dangerous substances.***

(5) The following measures are those specified for the purposes of paragraph (3)(b) -

- ***(a) the reduction to a minimum of the number of employees exposed;***
- ***(b) the avoidance of the propagation of fires or explosions;***
- ***(c) the provision of explosion pressure relief arrangements;***
- ***(d) the provision of explosion suppression equipment;***
- ***(e) the provision of plant which is constructed so as to withstand the pressure likely to be produced by an explosion; and***
- ***(f) the provision of suitable personal protective equipment.***

The measures in paragraph (4) are dealing with the design and use of malting equipment and operational procedures. Paragraph (5) however requires an understanding of the technical factors that control combustion, explosion prevention and explosion protection. These are considered in more detail in **Appendix 1.**

3.1 The Technical Aspects of Risk Assessment

Investigations required to evaluate ignition risk and to specify appropriate protective/preventative measures require:

- (a)- information on flammability characteristics of raw materials and malting products
- (b)- identification of potential ignition sources
- (c)-selection and specification of most appropriate explosion prevention/protection measures

3.1.1 Flammability Characteristics of barley and malt dust

The DSEAR do not require the provision of data for all flammability parameters but only on those that have been used to assess ignition risk and to design explosion protection systems. Critical parameters in most malting dust production are:

- **(a)** Dust Cloud Explosion Indices
- **(b)** Dust Cloud Minimum Ignition Energy
- **(c)** Dust Cloud Minimum Ignition Temperature
- **(d)** Dust Cloud Lower Explosive Concentration
- **(e)** Dust Layer Ignition Temperature

(See Section 2 Page 1)

3.1.2 Identification of Potential Ignition Sources

Identification of potential ignition sources is an essential part of DSEAR requirements. Operating experience indicates that the following can present a potential ignition risk in malting operations.

(1) Hot Working operations, naked flames
(2) Smoking matches/lighters
(3) Electrical equipment
(4) Static electricity
(5) Mechanical friction
(6) Barley drying and malt kilning.
(7) Burning material from upstream units

(The potential risk from these sources is discussed in APPENDIX 1.)

The list above contains typical potential ignition sources. It is not an exhaustive list, and consideration should be given to the possibility that other potential ignition sources could arise from time to time.

3.1.3 Selection of Safety Measures
Explosion prevention / protection can in principle be achieved by -
(1) Avoidance of Flammable Atmosphere
(2) Elimination of Ignition Sources
(3) Containment of Explosion
(4) Explosion Suppression
(5) Explosion Relief

The most appropriate basis of safety for a specific unit depends on -
(a) flammability characteristics of dust/fines
(b) type/design of plant
(c) operating conditions including foreseeable operator error
(d) the cost of the various options in the plant / operation under consideration

Compliance with DSEAR is best achieved by carrying out a full Hazard Assessment for each plant. Guidance on the factors that have to be taken into account in assessing risk and the selection of safety measures is given in Appendix 1.

Consideration should be given to the compilation of a dossier which:
- **describes the dangerous properties of each substance**
- **considers defined locations and what will be found there**
- **takes into account interactions that may affect the dangerous properties**

4. DOCUMENTATION
To avoid unnecessary work maltsters should make use of documentation already in existence as part of compliance with the existing Management of Health and Safety at Work Regulations (1999) (e.g. risk assessments, etc.). Note that this existing documentation will require updating to reflect the requirements of DSEAR

Documentation can be grouped under the following topics.
- Site management structure and employee listing
- Managerial safety strategy
- Employee training
- Common operational procedures, e.g.
    Permit to Work,
    Incidents and Emergencies procedures
    Site employee safety and accidents procedures,
- Area classification and specification of electrical equipment
- Assessment and prescription of safety measures for individual plant/operations.

4.1 The DSEAR Risk Assessment Document.
This document is required to identify the malting site that has been assessed, the nature of the potential hazards, and the basis of safety, its implementation and the individuals responsible for the different stages of the assessment. Essentially it brings together the risk assessment for the normal process and the additional considerations raised by the zoning decisions. Key points for any documentation are summarised below.

Key points for the DSEAR Risk Assessment Document:
(a) Title
Concise title to identify plant / operation being assessed.

(b) Responsible Personnel

(i) operator of the plant / process responsible for design and operating information.
(ii) people involved in assessment and having relevant competence to assess
(iii) people responsible for implementing safety measures
(iv) people responsible for auditing / monitoring safety measures and having relevant competence to audit

Ideally the responsible personnel should be current employees as they are most familiar with the process and equipment.

(c) Brief description of Plant /Process /Operations /Materials Processed

To indicate the situation covered by the assessment and safety measures.

(d) Assessment

(i) summary of information used in hazard assessment e.g. flammability characteristics of materials, ignition sources identified etc.
(ii) discussion of risk including poor operational procedures identified in the study.
(iii) discussion of risk reduction by substitution, alteration of the process etc.
(iv) consideration of possible safety measures.
(v) selected basis of safety (e.g. venting, suppression, no flammable atmosphere).
(vi) Design of safety measures

(e) Conclusions

(i) Basis of safety
(ii) Essential features of protective system.
(iii) Maintenance / inspection requirements.
(iv) Action in case of malfunction / fault condition.

4.2 Documentation for Area Classification to determine extent of ZONES

Documentation is required to indicate the extent of each zone and to specify the equipment suitable for use in them. Simple documentation could be based on:

(a) simple layout plan of each floor indicating the zoning
(b) mark the layout plan to show the location and extent of any zones, using the zone identifications given in BS EN 50281-3 and BS EN 60079-10
(c) Use Table 1 in Section 5 to help specify the zoning in maltings
(d) list the electrical equipment in each zone with its essential characteristics.
(i.e. Category 1, Category 2, Category 3, IP5X and IP6X)

4.3 Site Management Structure /Managerial Safety Strategy

Documentation is likely to be required at company and site levels. Whatever documentation format is most appropriate, important elements are -

(a) safety statement specifically concerned with fire and explosion hazards and how to control them.

(b) list / chart of people responsible for

(i) allocating responsibilities in the safety organisation.

(ii) people responsible for

- worker training,
- construction / maintenance / Permit to Work system

- control of accidents, incidents, emergencies
- electrical safety
- area classification and equipment selection
- control of individual plant assessments
- auditing the procedures and their implementation.

(iii) list of standard procedures

4.4 Worker Training

Documentation is required for

(a) an overall training plan in fire and explosion matters for:

-Production management,
-Engineers,
-Supervisors
-Operators.

(b) training procedures for general malting activity and for working on individual tasks/operations.

4.5 Permit to Work Procedure

Documentation will be concerned with

(a) conditions / situations in which a Permit should be used and the initiation procedure.

(b) persons responsible for assessing risk, prescribing safety measures in the proposed operation and issuing the Permit (the “competent person”).

(c) person responsible for control of work.

(d) procedure for control of contractors

(e) person responsible for, and procedure for terminating Permit and ensuring plant is handed back in safe condition.

4.6 Procedure for Control of Static Electricity

Documentation will show that:

(a) All metal plant items should be earthed.

(b) Fixed metal plant (e.g. silos etc.) should be earthed via their construction and should have a resistance to earth of less than 10 Ohms.

(c) Moveable metal plant (e.g. bins on wheels etc.) should be connected to earth via a robust metal clip and strap. The earth connection should be attached before an operation (e.g. filling a bin) commences and not removed until after it has been stopped. The resistance to earth should be less than 10 Ohms.

(e) The earth systems should be checked at periodic intervals and after any maintenance that involves the dismantling and reconnection of plant.

4.7 Procedure for Control of Accidents, Incidents, Emergencies

Documentation is required for:

(a) first aid procedures, facilities etc.,

(b) hazard identification alarms etc.,

(c) evacuation procedures

(d) control and maintenance of safety / fire equipment

(e) liaison with external bodies e.g. fire brigade

(f) other safety control matters appropriate to the site characteristics (i.e. Category 1, Category 2, and Category 3.)

5. IDENTIFICATION OF EXPLOSIVE ATMOSPHERES AND ZONING

The protection of workers from ignition of explosive atmospheres is a key element in both the European directive and DSEAR.

To fully comply with DSEAR the company is required to ensure:

(a) areas in the workplace in which an explosive atmosphere (gas or dust) could be present are identified.

(b) the frequency and duration of an explosive atmosphere in the workplace is assessed and the workplace divided into zones indicating this. (“Area Classification” or Zoning.)

(c) the installation in each zone of the type of equipment (mechanical and electrical) that will not introduce an unacceptable risk of ignition into the workplace.

(d) where necessary, areas classified into zones are marked with a specified “EX” sign at their points of entry.

(e) where employees work in zoned areas they are provided with appropriate clothing and footwear that does not create risk of an electrostatic discharge igniting the explosive atmosphere; although dust/fines are insensitive to ignition by discharges of static electricity from insulating plastics, dust/fines can be ignited if the energy is sufficient, and therefore proper earthing is required of all conductors, including personnel

(f) before coming into operation for the first time, areas where hazardous explosive atmospheres may be present are confirmed as being safe (verified) by a person (or organisation) competent in the field of explosion protection. The person carrying out the verification must be competent to consider the particular risks at the workplace and the adequacy of control and other measures put in place.

5.1 Area Classification

To indicate the frequency and duration of an explosive dust atmosphere the plant has to be divided into zones using the following definitions.

Zone 20

A place in which an explosive atmosphere in the form of a cloud of combustible dust in air is present continuously, or for long periods or frequently. Typically this would be in excess of 1000 hours or occurrences per year.

Zone 21

A place in which an explosive atmosphere in the form of a cloud of combustible dust in air is likely to occasionally occur in normal operation. Typically this would be between 100 and 1000 hours or occurrences per year.

Zone 22

A place in which an explosive atmosphere in the form of a cloud of combustible dust in air is not likely to occur in normal operation but, if it does occur, will persist for a short period only. Typically this would be between 10 hours to 100 hours or occurrences per year.

Safe

A place in which neither dust clouds nor powder layers are present for a significant length of time, typically less than 10 hours or occurrences a year

.

Notes

1. Layers, deposits and heaps of combustible dust must be considered as any other source which can form an explosive atmosphere.

2. "Normal operation" means the situation when installations are used within their design parameters.

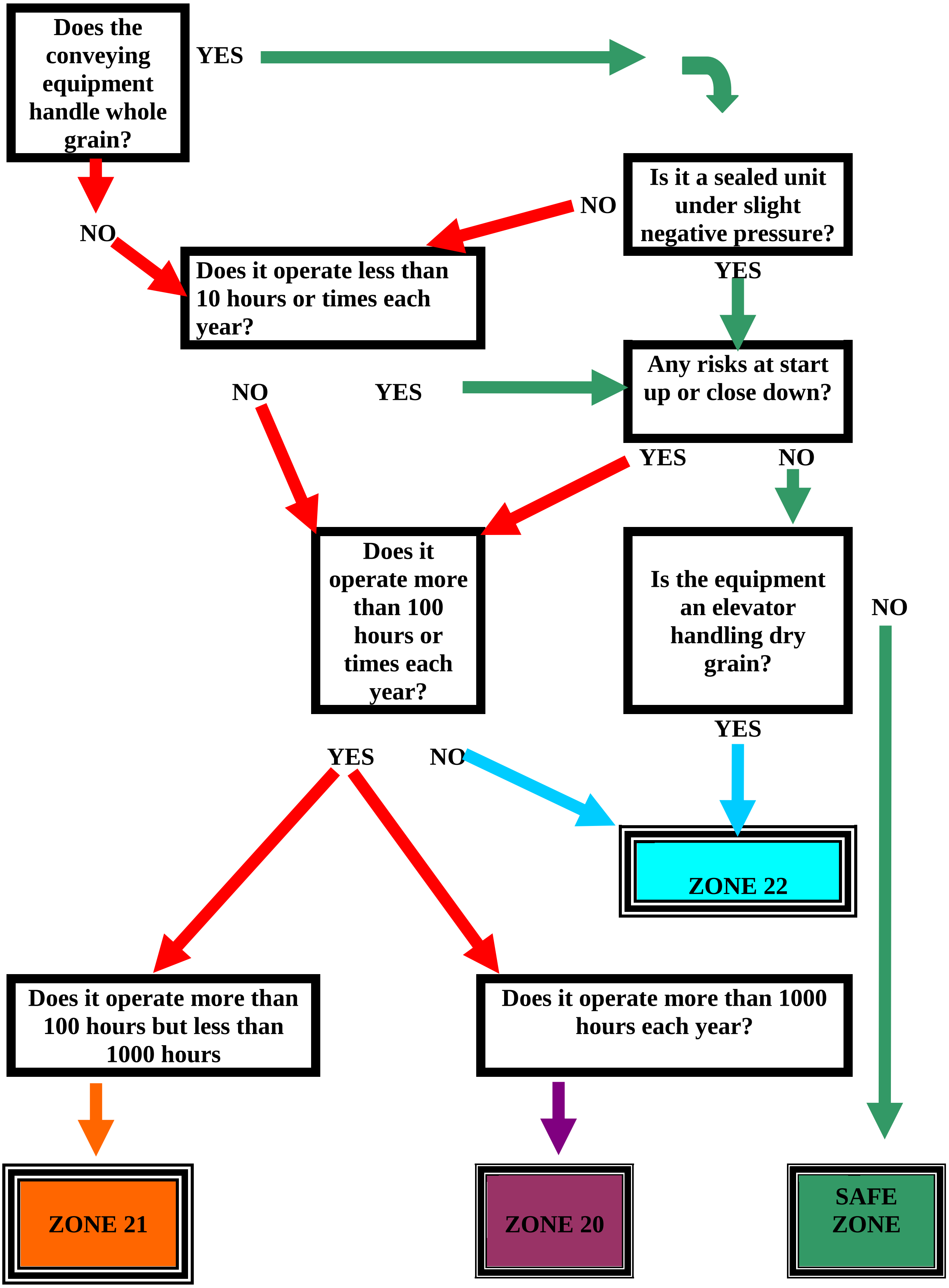
3. The above time indications assume continuous operation. If a plant is only used for 10 hours per year, and an explosive atmosphere is present for 5 hours, then it is a Zone 20, as it is effectively present continuously or for long periods with respect to the operational hours.

4. An indication of a model to evaluate the risk of dust in maltings is shown on the following page:

Areas classified into ZONES must be marked with a specified 'EX' sign at their points of entry, as shown below:

Although the end result of a ZONING assessment may be "SAFE", consideration should be given to the potential for accumulation of materials on warm surfaces by other deposition methods. Such deposits may decompose and become adherent, making cleaning difficult. The adherent deposit may subsequently become thermally unstable.

The UK Malting industry's approach to DSEAR explosion risk assessment.



6 THE SELECTION OF SUITABLE EQUIPMENT FOR ZONES

6.1 The classification of an area determines the standard of electrical equipment that is required to be used in it.

The level of housekeeping operated in the area can also impact on the risk assessment.

In general terms area classification in the malting industry is likely to be based on:
(i) Zone 22 generally in the building area where grain or malt is moved, where the handling equipment is not sealed or operating at a positive pressure
(ii) Zone 21 a limited distance (e.g. 1-2m) around points where dust could be emitted in normal operation occasionally.
(iii) Zone 20 inside certain plant items (e.g. inside silos).

The selection of equipment both electrical and mechanical for use in hazardous areas should be based on the categories specified in DSEAR as follows, unless the risk assessment finds otherwise;
Zone 20: Category 1 equipment
Zone 21: Category 1 or 2 equipment
Zone 22: Category 1, 2 & 3 equipment

Category 1 equipment is made for a very high level of protection to ensure the required protection even in the event of:
• the failure of one means of protection, when an independent second means provides the requisite level of protection,
• the level of protection is still assured even if two faults happen at the same time.

Category 2 equipment is designed to ensure a high level of protection to the point that equipment malfunction will not compromise the level of protection.

Category 3 equipment is designed to ensure a normal level of protection such that it will not represent a source of ignition in normal operations.

The higher the level of protection provided by equipment the more sophisticated its design, the more extensive its testing and correspondingly the greater the cost.

Uncategorised equipment may be allowed where:

(a) alternative effective precautions are in place to control the risk;
(b) workers can be excluded from the hazardous area and will not be at risk;
(c) equipment of the required category is not available, but a lower category can be used in conjunction with other protective measures.

6.2 The selection of electrical apparatus for use in the presence of combustible dusts is based on the following safe-guarding methods:

(a) enclosing the apparatus so as to limit the amount of dust which may enter the enclosure and come into contact with sources of ignition. Two specifications are in common use in the malting industry:

IP5X - dust protected enclosures
IP6X - dust tight enclosures.

The equipment type suitable for use in each zone is summarised below:

Zone 20 Category 1D

Zone 21 Category 1D
Category 2D
IP6X

Zone 22 Category 1D
Category 2D
Category 3D
IP6X
IP5X

and
(b) restricting the maximum surface temperature of the apparatus to prevent it acting as a source of ignition for dust clouds and dust layers. In all zones the maximum temperature of surfaces on which dust layers can form must not exceed:

(i) ⅔ of the Dust Cloud Ignition Temperature
(ii) 75°C below the Layer Ignition Temperature

It is assumed that the thickness of any dust layers will not exceed 5mm.

(See first page of SECTION 2 on 'Flammable Material List)

7. ORGANISATIONAL MEASURES

Requirements under General Safety Measures, Schedule 1, as directed under Regulation 6 (8), which require that:

The employer shall, so far as is reasonably practicable, take the general safety measures specified in Schedule 1, subject to those measures being consistent with the risk assessment and appropriate to the nature of the activity or operation.

7.1 Dealing with Organisational Measures, (i.e. control of work activity).

Schedule 1, point 6 states the following:

The application of appropriate systems of work including -

(a) the issuing of written instructions for the carrying out of work; and

(b) a system of permits to work with such permits being issued by a person with responsibility for this function prior to the commencement of the work concerned, where the work is carried out in hazardous places or involves hazardous activities.

7.2 Written Instructions

In essence an employer is required to provide employees with written instructions that will ensure their safety at work. Employees working with dangerous substances should be provided with documentation on:

(a) the potential hazards in the operations in which they are involved.
(b) the measures taken to control the risks.
(c) the actions required of the employee to fully implement the safety measures.
(d) the actions to be taken in the event of an operator error/onset of a potentially hazardous situation.

In practice the required information / documentation could be integrated with the existing operating instructions / procedures in a company. This will ensure that control of safety is a normal part of an operator's activity.

7.3 Permit to Work Systems

Maltsters will already have Permit to Work systems in place from previous UK legal requirements, but ATEX now spreads this practice across the EU. Permit to Work systems are required when non-standard operations or maintenance work are being carried out e.g.

(i) General maintenance work e.g. working at heights, mechanical isolation of equipment etc.

(ii) Hot work e.g. welding, cutting, grinding, naked flames, pneumatic hammers, drills etc. (Note that welding using a common earth point has caused fires and explosions in remote plant when arcing has occurred in other poorly earthed plant used as the welding return path to earth.)

(iii) Confined space entry.

(iv) Electrical isolation. (Consider the adequacy of the earthing - some installations rely on electrical earth paths for static earthing - this may not be safe as earth faults can result in sparking in equipment, and such sparking is not electrostatic in source - it is high current mains electricity.)

In activities such as these a specific risk assessment of the proposed activity will be required and written instructions (the Permit to Work) given to employees that define the conditions necessary to ensure safety.

In establishing a Permit to Work System an employer has to give consideration to -

(a) conditions/situations in which a Permit should be used and the initiation procedure.

(b) persons responsible for assessing risk, prescribing safety measures in the proposed operation and issuing the Permit.

(c) person responsible for control of work.

(d) procedure for control of contractors

(e) person responsible for, and procedure for terminating the Permit and ensuring plant is handed back in safe condition.

DSEAR requires that a person assessing risk, prescribing safety measures and issuing a Permit should be "Competent in the field of explosion protection as a result of their experience or any professional training or both".

8. WORKER TRAINING

Regulation 9 defining the employer's responsibility with respect to information, instruction and training is reproduced below.

(1) Where a dangerous substance is present at the workplace, the employer shall provide his employees with -

(a) suitable and sufficient information, instruction and training on the appropriate precautions and actions to be taken by the employee in order to safeguard himself and other employees at the workplace;

(b) the details of any such substance including -

(i) the name of the substance and the risk which it presents;

(ii) access to any relevant safety data sheet; and

(iii) legislative provisions which concern the hazardous properties of the substance;

and

(c) the significant findings of the risk assessment.

(2) The information, instruction and training required by paragraph (1) shall be –

(a) adapted to take account of significant changes in the type of work carried out or methods of work used by the employer; and

(b) provided in a manner appropriate to the risk assessment.

The Regulations do not provide detailed guidance on training methods required for workers in hazardous areas. However training will need to be sufficient to ensure that personnel at each level (operators, supervisors, line management etc.) are trained to a degree that enables them to understand potential explosion risks, the reason for safety measures and the actions required of them. It will also be necessary to maintain training records and to be able to demonstrate the competency of personnel. The organisation of training and the associated documentation depend on the existing practices in the company and can be integrated with them.

HS(G)65 Successful Health and Safety Management provides guidance on organising and training for health and safety.

9. PROVISION FOR ACCIDENTS, INCIDENTS AND EMERGENCIES

Regulation 8 is concerned with provision for accidents, incidents and emergencies stating that:

(1) Subject to paragraph (4), in order to protect the safety of his employees from an accident, incident or emergency related to the presence of a dangerous substance at the workplace, the employer shall ensure that -

(a) procedures, including the provision of appropriate first-aid facilities and relevant safety drills (which shall be tested at regular intervals), have been prepared which can be put into effect when such an event occurs;

(b) information on emergency arrangements, including -

(i) details of relevant work hazards and hazard identification arrangements, and

(ii) specific hazards likely to arise at the time of an accident, incident or emergency, is available;

(c) suitable warning and other communication systems are established to enable an appropriate response, including remedial actions and rescue operations, to be made immediately when such an event occurs.

(d) where necessary, before any explosion conditions are reached, visual, or audible, warnings are given and employees withdrawn; and

(e) where the risk assessment indicates it is necessary, escape facilities are provided and maintained to ensure that, in the event of danger, employees can leave endangered places promptly and safely.

(2) Subject to paragraph (4), the employer shall ensure the information on the matters referred to in paragraph (1)(a), (c) to (e) and the information required by paragraph 1(b) is -

(a) made available to relevant accident and emergency services to enable those services, whether internal or external to the workplace, to prepare their own response procedures and precautionary measures; and

(b) displayed at the workplace, unless the results of the risk assessment make this unnecessary.

(3) Subject to paragraph (4), in the event of an accident, incident or emergency related to the presence of a dangerous substance at the workplace, the employer shall ensure that -

(a) immediate steps are taken to -

(i) mitigate the effects of the event,

(ii) restore the situation to normal, and

(iii) inform those of his employees who may be affected; and

(b) only those persons who are essential for the carrying out of repairs and other necessary work are permitted to the affected area and they are provided with -

(i) appropriate personal protective equipment and protective clothing; and

(ii) any necessary specialised safety equipment and plant, which shall be used until the situation is restored to normal.

(4) Paragraphs (1) to (3) shall not apply where -

(a) the results of the risk assessment show that, because of the quantity of each dangerous substance at the workplace, there is only a slight risk to employees; and

(b) the measures taken by the employer to comply with his duty under regulation 6(1) are sufficient to control that risk.

This can be simplified to state that the Regulations require employers to assess the size and likelihood of the effects that may result from any accident, incident, emergency or other unexpected event involving dangerous substances present at the workplace. On the basis of this assessment the employer should ensure that appropriate emergency arrangements (both technical and organisational) are in place and maintained to minimise the effects of the event, to safeguard employees and any others present at the workplace, and then to be able to restore the situation to normal as soon as practicable. The responsibility for achieving this re-adjusted position will not be solely with the employer, but will also involve the relevant accident and emergency services, as employers are required to have liaised with those local bodies to determine what assistance they can provide.

To ensure compliance with DSEAR it is advisable for employers to review their existing arrangements for the control of incidents, accidents and emergencies.

APPENDIX 1
GUIDANCE ON SELECTION OF EXPLOSIBLE PREVENTION/PROTECTION SAFETY MEASURES
(Much of this information is by courtesy of nabim from information supplied by their consultants Burgoyne and modified to maltings data.)

This guidance is intended to assist the malting industry in the selection of the most appropriate basis of safety for installations by indicating the important technical factors.

These lists are not intended to, nor can they provide a full hazard assessment of all factors influencing the dust explosion hazard in a specific plant - operation situation. Their role is solely to give guidance.

A.1.1 SAFETY BASED ON ELIMINATION OF FLAMMABLE ATMOSPHERES

(A) Basis of Safety

Can the flammable atmosphere be avoided by maintaining the dust concentration below the Lower Explosible Limit?

(B) Operating With Dust Concentration Below the Lower Explosible Limit

(1) What is the Lower Explosion Limit for the malting operation being undertaken? (Typical values for barley dust are 125 gm^{-3} and for malt dust 60 $g\ m^{-3}$).
(2) Can the dust concentration of particles less than 100 µm be maintained below the Lower Explosible Limit during all normal operations including start up and shut down? (Barley and malt dust are ~9.5 µm, and dust particles under 100 µm in aerodynamic diameter will readily take part in a dust explosion at adequate concentration and with an ignition source.)
(3) Are there dust layers/deposits present in the plant that could be raised into a flammable dust cloud (e.g. by air turbulence, by pressure from an explosion in a connected vessel).

A.1.2 SAFETY BASED ON AVOIDANCE OF IGNITION SOURCES

Safety based on the avoidance of ignition sources does not, by definition, require the use of specialised explosion protection equipment. Guidelines of the type produced for the other bases of safety are not appropriate in the case of this one. Identification and elimination of all sources of ignition is difficult to guarantee and can only be accepted as a basis of safety after careful analysis of all aspects of plant design, plant operation and dust flammability characterisation.

The following guidelines list the common ignition sources and the relevant queries.

(A) Hot Work / Flames / Smoking / Matches / Welding / Cutting

(1) Can these sources be controlled by procedural means and Permit to Work Systems?

Note: Smoking should not be permitted in any area where food products are handled, irrespective of the stage of the process.

(B) Electrical Equipment

(1) Has the possibility of dust clouds being present been established using a formal Area Classification Procedure?

(2) Are the equipment enclosures suitable for their zone location (i.e.Category1, Category, 2 Category 3, IP5X, IP6X).

(3) Does the maximum surface temperature of the equipment satisfy both the following:

- **(i)** less than 2/3 rds of Dust Cloud Ignition Temperature?
- **(ii)** less than Layer Ignition Temperature minus 75°C?
- **(iii)** are all powder deposits less than 5mm deep?

Note: A dust cloud of 100 g m^{-3} typically corresponds to a depth of only 1 mm, so the thickness of 5 mm only refers to the potential for ignition of a dust layer by the heat emanating from the electrical equipment. Minimising the layers by good housekeeping reduces the risk of explosion at source.

(C) Static Electricity

(1) Has a formal electrostatic hazard assessment been carried out and consideration given to:

- **(i)** correct and adequate earthing of plant?
- **(ii)** need to earth personnel?
- **(iii)** possibility of electrostatic discharges from moving grain and powders?
- **(iv)** possibility of ignition risk associated with use of plastics?

Notes: Incendive discharges can by drawn from insulating plastics, which have an equivalent energy of about 4 mJ, so can ignite sensitive atmospheres. Guidance on the maximum area of plastic permitted in various zones is given in PD CLC/TR 50404:2003.
Where high transfer velocities are used, then expert advice should be sought on the potential for propagating brush discharges to occur.

(D) Mechanical Friction

(1) Have all sources of mechanical friction / impact under normal and abnormal operating conditions (e.g. elevator belt slippage, grain blockages etc.) been identified? (If potential sources of mechanical friction are present then it is unlikely that avoidance of ignition sources will be an acceptable basis of safety).

(2) Is equipment fabricated from aluminium, magnesium, titanium or light alloys containing them present in the plant? (the thermite reaction is a potent ignition source).

Notes: The thermite reaction occurs between aluminium, magnesium, titanium or light alloys containing them, and oxygen-containing materials such as rust, red lead etc. A "smear" of aluminium on rusty steel can produce a thermite spark on impact.
Where the use of aluminium equipment cannot be avoided, guarding to prevent contact or impact should be considered.

(E) Burning Material

(1) Can burning material from upstream units enter the plant?

(F) Other Potential Ignition Sources

(1) Could any other potential sources of ignition be present during normal or abnormal operation of the plant?

A.1.3 SAFETY BASED ON EXPLOSION CONTAINMENT

This approach has some relevance to pelletising plants and malt mills.

(A) Flammability Characteristics of Material

(1) What values of Maximum Rate of Pressure (Kst) and Maximum Explosion Pressure (Pmax) are used in calculations?

Notes: This data is only relevant to the designer of the equipment
Kst for generic barley dust is 72 Bar m/s, and 97 Bar m/s for generic malt dust.
Pmax for generic barley dust is 9.1 Bar and 7.7 Bar for generic malt dust. (**See SECTION 2, page 1, 'Flammable Material List'**)

(2) Are data based on tests on the actual material being processed or on published (generic) information? If the latter are used, how is this justified?

(B) Mechanical Strength of Equipment

(1) What is the mechanical strength of the equipment i.e. what internal explosion pressure can it withstand?

(2) Is the value based on -

(i) pressure resistant criteria i.e. no deformation in the event of an explosion?

or

(ii) pressure shock resistant criteria i.e. deformation could occur but the vessel would not rupture?

(3) Have all connections been included in strength specification (e.g. flanges, door catches, flexible components, joints, bolts etc.)?

(4) Is flame emission from joints or connections possible and been taken into account?

(5) Has account been taken of any pressure piling?

(6) Has account been taken of pressure/flame effects between interconnected vessels?

(7) What calculation methods have been used? Are the methods valid for the equipment under consideration?

(C) Configuration of the Plant

(1) Has the plant been treated as a single or multi-volume enclosure?

(2) If the plant is multi-volume have the separate volumes been mechanically isolated one from another with devices that can withstand the maximum pressure that can be developed in an explosion.

(3) Have all access points (e.g. sample points, grain flow divergence points) been designed to withstand the maximum pressure developed in an explosion.

(4) Have all parts of the plant been mechanically isolated from weaker units (e.g. bag filters, cyclone discharge points to containers etc.) with devices that can withstand the maximum pressure developed in an explosion?

(D) Determination of Maximum Pressure Possible in an Explosion

(1) What methods have been used to determine the maximum pressure in an explosion in the plant?

(2) Has account been taken of:

(i) the size of each volume and the volume of each unit of the plant?

(ii) the effect of connections between vessels not mechanically isolated? - consider propagation of the explosion from one vessel to another.

(iii) the effect of connections between vessels? - consider propagation of the explosion from one vessel to another.

(iv) methods of isolating each section of plant from those connected to it?

(v) the effect of internal components such as baffles, shelves, trays, cyclones, agitators, chutes, etc that could influence flame propagation and pressure development? Expert opinion should be sought if vessels have any internal components.

A.1.4 SAFETY BASED ON EXPLOSION SUPPRESSION

This approach is not generally adopted in the malting industry.

(A) Flammability Characteristics of Material

(1) What values of K_{st}, P_{max} and Dust Cloud Ignition Temperature are used in calculations? (**See SECTION 2, page 1, 'Flammable Material List'**)

(2) Are data based on tests on material being processed or on published (generic) information? If the latter are used, how is this justified?

(B) Mechanical Strength of Equipment

(1) What is the mechanical strength of the equipment i.e. what internal explosion pressure can it withstand?

(2) Is the value based on -

(i) pressure resistant criteria i.e. no deformation in the event of an explosion?

or

(ii) pressure shock resistant criteria i.e. deformation could occur but the vessel would not rupture?

(3) Have all connections been included in strength specification (e.g. flanges, door catches, flexible components etc.)?

(4) Which calculation methods have been used?

(C) Detection of Explosion

(1) What type of detectors are proposed?

(i) is detection based on pressure rise?

(ii) is detection based on rate of pressure rise?

(2) Are the detectors suitable for the zone in which they are located?

(3) What is the pressure at which the system will be activated?

(3) What are the pressure variations in the plant during normal operation?

(4) In view of the operation and activation pressures in (2) and (3):

(i) will spurious trips be avoided?

(ii) what frequency of spurious trips can be expected?

(5) How were the positions of the detectors determined?

(6) What is the longest response time between detector activation and full suppression of an explosion originating in any part of the system?

(7) Does the location of the detectors take account of burning material initiating an explosion in a downstream vessel?
(8) How are the detectors tested?
(9) Who will maintain, calibrate and repair the detectors?

(D) Suppression of the Explosion

(1) Which suppressant (halon, powder, steam or water) is to be used? What are the reasons for the choice?
(2) Is the proposed suppressant compatible with the grain or dust being handled in terms of:
- **(i)** contamination / recycling material?
- **(ii)** ease of cleaning?

(3) How was the geometric deployment and size of explosion suppressors determined for the volume(s) to be protected?
(4) Does the deployment of the explosion suppressors take account of burning material initiating an explosion in a downstream vessel?
(5) Does the system prevent the propagation of an explosion into connected vessels?
(6) How is the suppressant released? If detonators are required, has a suitable storage system and explosives licence been provided?

(E) Control System for suppressant systems

(1) Is the control system designed such that activation of any detector causes suppressant to be injected throughout the system or has the plant been divided into independent zones?
(2) By the use of interlocks, does the control system prevent operation of the plant unless the explosion suppression system is fully functional?
(3) Is the plant fully protected in the event of a power failure?
(4) Does the system ensure the plant is shut down on the activation of any detector and that the plant is fully protected during the time to shutdown?
(5) When the system fails, what manner does the failure take?
(6) Does the entire system comply with IEC 61508 "Functional safety of electrical/ electronic/ programmable electronic safety-related systems", Parts 1, 2, and 3, and with IEC 61511 "Functional safety - Safety instrumented systems for the process industry sector"?

(F) Servicing / Maintenance of suppressant systems

(1) What is the frequency of routine servicing/maintenance?
(2) What are the contractual conditions imposed by the supplier?
(3) What is the plant downtime for:
- **(i)** routine maintenance / servicing?
- **(ii)** re-establishment after spurious trip?
- **(iii)** re-establishment after suppressed explosion?

A.1.5 SAFETY BASED ON EXPLOSION RELIEF

(A) Flammability Characteristics of Material

(1) What values of K_{st} and P_{max} are used in calculations?
(2) Are data based on tests on material being processed or on published (generic) information? If the latter are used, how is this justified?

(B) Mechanical Strength of Equipment

(1) What is the mechanical strength of the equipment i.e. what internal explosion pressure can it withstand?

(2) Is the value based on -

(i) pressure resistant criteria i.e. no deformation in the event of an explosion?

or

(ii) pressure shock resistant criteria i.e. deformation could occur but vessel would not rupture?

(3) Have all connections been included in strength specification (e.g. flanges, door catches, flexible components etc.)?

(4) Which calculation methods have been used?

(C) Vent Area

(1) Which calculation method has been used?

(2) Does vent area calculation take account of:

(i) discharge duct on clean side of vent?

(ii) effect of directly connected vessels?

(iii) excessive turbulence should this be present?

(iv) location of ignition source in the vessel?

(v) internal obstructions within the vessel?

(vi) obstructions near the open end of the duct?

(D) Vent Opening Pressure

(1) What is the type of vent (e.g. bursting disc, rigid panel etc.)?

(2) What is the opening pressure - how was it determined?

(3) What is the mass of vent opening? It should not exceed an inertia of $10kg/m^2$ without justification.

(4) Is the vent opening hinged? Hinged panels require expert advice as the fastening, hinge location and moment of inertia of the panel affect the performance.

(5) Will the vent opening become detached and fly free when it vents? Will any restraints be adequate?

(6) What consideration has been given to factors that could impede efficient venting?

e.g.

(i) rigid panel blocking discharge duct?

(ii) weather sealing / protection?

(iii) snow /ice on outside vents?

(iv) any other factors?

(7) How will the vent opening be replaced, and by whom? Are they competent to carry out the work?

(E) Vent Location

(1) Is the vent located in such a place that flame / pressure from an explosion in any part of the volume has unimpeded access to it (e.g. not impeded by filter bags)?

(2) Is there an adequate unrestricted volume for the vented gases?

(3) Does the vent go directly to the outside of buildings? It is usually unacceptable to discharge an explosion vent into an occupied building.

(F) Safe Discharge Area

(1) Does the vent discharge to an area safe with respect to

(i) protecting personnel and safety-critical equipment from flame, hot gases and pressure?

(ii) protecting adjacent buildings from unacceptable damage?

(iii) emitted flame or burning powder not initiating secondary fires or explosions?

(iv) shrapnel/flying debris from the vent opening?

(G) Reaction Forces on Plant

(1) What reaction forces will the installation experience?

(2) How is the installation designed to withstand such forces?

APPENDIX 2
OTHER USEFUL INFORMATION.
(Much of this information is by courtesy of nabim from information supplied by their consultants Burgoyne, and modified to maltings data.)

A5.1 Explosion class ratings:

Explosion Class	Rate of Pressure Rise (Kst) Value (Bar.m.sec^{-1})	Explosion Violence
St.0	0	Nil
St.1	1-200	Weak/Moderate
St.2	201-300	Strong/Violent
St.3	>300	Violent

A5.2. SAFETY BASED ON EXPLOSION RELIEF
The basic principle of venting is that, if a dust explosion occurs in a vessel, a vent of sufficient area should open rapidly allowing unburnt dust and explosion products to escape. This limits the pressure rise within the vessel to a level that does not cause rupture or serious distortion of the vessel and that minimises the pressure passing to connected vessels. The vent must be sited to discharge flame, pressure and products into an area where they cannot injure personnel, damage other plant nor produce a hazardous Secondary Explosion.

The factors that have to be taken into account are;

(i) Rate of pressure development / maximum pressure in explosion,
(ii) Mechanical strength of the equipment,
(iii) Maximum permissible explosion pressure,
(iv) Area of vent,
(v) Interconnected vessels.
(vi) Type of vent and its opening pressure,
(vii) Location of the vent,
(viii) Safe discharge area,
(ix) Reaction forces on plant when vent opens.

A5.3 Rate of Pressure Development
The information from Appendix 3 indicates that for barley and malt dust, vents designed for K_{st} = 100 bar.m sec $^{-1}$ and P_{max} = 9.2 bar.g should provide adequate protection in most situations.

A5.4 Mechanical Strength of Equipment
This determines the maximum permissible explosion pressure (P_{red}) inside the equipment. As in the case of safety based on containment equipment can be designed according to two approaches to withstand explosion pressure:

(i) Pressure Resistant: the plant is designed to prevent permanent deformation or rupture. Design techniques akin to those used for pressure vessels (e.g. B.S. 5500) should be used,
(ii) Pressure Shock Resistant: the plant is designed to withstand the explosion pressure without rupture but may be subject to permanent deformation in the event of an explosion occurring. Detailed design methods using this concept are under development but not yet complete. It is generally accepted that the traditional strength calculation methods can be relaxed to the extent of using 90% yield stress as opposed to 50% or less.

N.B. The above approach is only valid for ductile steel vessels: it should not be used for brittle cast iron vessels

Pressure Shock Resistant vessels can involve reduced capital costs but, in the event of an explosion, production will be interrupted whilst plant is repaired and/or replaced. In view of the low frequency of explosions in the industry it appears reasonable to use Pressure Shock Resistant designs.

The mechanical strength of equipment should be provided by the manufacturers.
For old equipment where manufacturers' data is not available it may be necessary to carry stress / strength analysis as indicated in (a) or (b) above.

A5.5 Reduced Explosion Pressure (Maximum Allowable Pressure)
The vent has to be designed so that the reduced explosion pressure (P_{red}) developed in the vented explosion does not cause unacceptable damage to process plant units.

It should also be kept as low as practical to;

(i) reduce the extent to which flame and pressure are emitted from the vent and so reduce the extent of the discharge area,
(ii) minimise the effect of pressure piling between interconnected vessels,
(iii) reduce the vessel strength requirements and so reduce costs.

In practice these requirements are normally met by using equipment with pressure strength in the range 0.3 - 2.0 bar.g and designing the vent to ensure that the maximum reduced explosion pressure does not exceed the mechanical strength of the equipment.

A5.6 Area of Vent
Until fairly recently the preferred method for calculating vent area was the K_{st}/Nomograph approach. This was based on an easy to use graphical technique. However it tended to give vent areas that were conservative.

A European standard method for calculating vent area is in the final stages of preparation. This will be the preferred method.
The vent area is calculated from the following equation.

$$A_v = \left[3.264 \ x \ 10^{-5} \ P_{\max} K_{st} \ P_{redmax}^{-0.569} + 0.27\left(P_{stat} - 0.1\right) P_{redmax}^{-0.5}\right] V^{0.753}$$

$$x \left[1 + \left(-4.305 \ \log \ P_{redmax} + 0.758\right) \log \ (L/D)\right]$$

A_v = area of vent (m^2)
P_{max} = maximum Explosion Pressure for dust (bar)
K_{st} = maximum rate of pressure rise (bar.m/sec)
$P_{red\ max}$ = maximum permissible vented explosion pressure (bar)
P_{stat} = opening pressure of vent cover (bar)
L = length of vessel (m)
D = equivalent diameter (D)
V = vessel volume (m^3)

An alternative is to use the method produced by the Institution of Chemical Engineers, detailed in the book *Dust Explosion Prevention and Protection: A Practical Guide*, IChemE, 2002 Edition, J Barton (Editor) ISBN 085295 410 7. This should be the basic design reference for new plant. Also, software is available for a proprietary method such as Dust Expert 2, produced by the Health and Safety Executive.

The design of vents and their sizing should only be undertaken or checked by a competent person.

A5.7 Interconnected Vessels

The above is only valid for single volume vessels. When two or more vessels are interconnected without mechanical isolation between them, then pressure piling effects have to be considered.

In assessing the increased pressure due to pressure piling consideration has to be given to the pressure developed in the connecting pipeline and the vent area required in each vessel to ensure P_{red} is below the strength of the vessel.

Both are controlled by complex interaction between flame propagation and pipe/vessel dimensions. The means of predicting the effect of pressure piling in all plant configurations are not available.

Limited studies have been carried out and the proposed European standard contains the following guidance for flour type powders.

(1) Pressure Developed in Pipeline

The pressure developed (P_{red}) in a pipe at a distance L from the vessel in which an explosion occurs is given by the equations.

(a) For K_{st} <100 bar m/sec

$L = D \times [324.8 \times (1-\exp(-0.1072 \times P_{red}))]$

(b) For Kst 110< K_{st} <200 bar m/sec

$L = D \times [88.57 - 81.99 \times \exp(-0.1640 \times P_{red})]$

These can be applied when P_{redmax} <0.5 bar and pipe diameter is between 0.2 and 0.6m.

(2) Venting of Connected Volumes

When K_{st} <150 bar.m/sec then a vent area vessel volume ratio ($A_V/V_{2/3}$) greater than 0.25 will limit the $P_{red\ max}$ to 0.5 bar.

The vent giving this ratio must be fitted to each vessel. This approach may be used with vessel volumes up to 20m^3 provided P_{stat} is <0.1 bar.

Expert advice should be sought where there are interconnected vessels. For plant / product combination outside the above constraints no detailed guidance on the effect of pressure piling is available. It is being increasingly recommended that connecting pipes should contain explosion barriers.

A5.8 Type of Vent and Opening Pressure

The vent can be;

(i) a bursting disc or panel that ruptures and opens at a pre-determined pressure rise,

(ii) a rigid panel or door that opens at a predetermined pressure rise and has an inertia of 10kg/m^2 or less.

If a door or rigid panel is used precautions are required to ensure;

(i) the door cannot freeze shut during cold weather,

(ii) the door cannot block the discharge duct,

(iii) the door does not become a dangerous missile when it opens.

Note: Where a door or rigid panel is used, the restraint will be subjected to very large impact loadings when the door opens, and simple wires or chains will usually be insufficient to adequately restrain it. Expert guidance should be sought to ensure the adequacy of any restraining device.

The vent should open at the lowest pressure compatible with the normal operation of the plant. *(In flour processing units opening pressures of 0.05 and 0.10 barg are normally recommended for the concrete vessels, bin tops and steel vessels in order to minimise the vessel strength requirements and minimize discharge areas.)*

A5.9 Location of the Vent

The vent aperture should be located such that flame, originating in any part of volume to be protected, has unimpeded access to the vent. In bag filters for example the length and distribution of the bags should be such that flame and pressure originating in the open volume below the bags can “see” and have unobscured passage to the vent.

A5.10 Discharge Area

On activation of the vent the following occurs:

(a) flame is emitted from the vent into the surrounding area.

(b) pressure is emitted from the vent into the surrounding area.

(c) unburnt powder emitted through the vent can disperse into a cloud and ignite causing a secondary dust explosion in the surrounding area.

(d) layers of dust in the surrounding area can be roused into a dust cloud by the pressure wave, ignited and produce a secondary dust explosion.

An acceptable vent system must ensure that adjacent plant and personnel are protected from harmful effects associated with all of the above. This is a key requirement for the use of venting as the basis of safety.

In the HSE Publication "Safe Handling of Combustible Dusts" (published 1994 due to be re-issued) the need to protect plant, buildings and people from vented dust explosions is emphasised. It is stated that:

"Explosion vents which discharge inside a building will give people inside the building little protection from the explosion. The usual solution is to fit a duct to lead the explosion to a safe place in the open air" (Page 11).

"Sometimes it may not be practical to site explosion prone plant where it can relieve to a safe place in the open air. In this case the consequences of an explosion within the building need to be very carefully considered. Explosion vents should not relieve into an area that is regularly occupied. Suitable plant automation may remove the need to visit vulnerable areas while the plant is running" (Page 13).

The building itself may be vulnerable to a pressure rise from either a primary or secondary explosion. In the past, buildings with load bearing brick or stone walls have collapsed following dust explosions with much loss of life. A suitable choice of building design will allow a building to relieve a pressure wave without major damage. This may be achieved by fitting areas of open louvres, roof or wall panels of light construction lightly attached or plastic glazing weakly secured to its frames" (Page 15).

German guidance given in V.D.I. 3673 *"Pressure Venting of Dust Explosions"*(1995) states unequivocally

"If pressure venting is applied to equipment installed in enclosed areas, then venting has to be done through a pipeline (so called vent duct) to outside in a safe direction" (Page 29). The draft European standard echoes this requirement.

Where possible, explosion vents should be ducted to outside the building.

The presence of a duct influences the reduced explosion pressure / vent area relationship due to back pressure effects and has to be taken into account when designing relief systems.

Procedures for designing vent systems with ducts are given in IChemE Book "Dust Explosion - Prevention and Protection" (2002) and they are likely to form the basis for European guidelines.

In any situation where it is impractical to vent outside a building consideration has to be given to:

(a) segregating the units fitted with vents by barriers - i.e. walls that can withstand pressures up to the maximum vented explosion pressure and secondary explosion pressures.

(b) ensuring no dust layers are present in the discharge areas that can be roused into dust clouds.

(c) excluding personnel from the discharge areas when the units are operating.

(d) replacing all glass by plastic sheet and fitting louvres or relief panels in walls.

(e) confirming that the solid walls, floors and ceilings of the building can withstand the maximum vented explosion pressure and secondary explosion pressures.

A5.11 Reaction Forces

If an explosion occurs the vented vessel or structure will experience reaction forces in the opposite direction to the gas outflow when the vent opens.

The vessel or structure should therefore be designed to withstand a reaction force / impulse. The draft European standard (EN14491) includes the following:
The maximum recoil force can be calculated using the equation:

$$F_{Rmax} = 119 \times A \times P_{red}$$

Where
F_{Rmax} is the recoil force, in kN
A is the physical area of the vent
P_{red} is the maximum reduced explosion over-pressure, in bar

The total recoil force can be considered as a force applied at the geometric centre of the vent. Installation of vents of equal area on opposite sides of a vessel may in some instances compensate for recoil forces, but this cannot be depended upon to prevent thrust in one direction, as one vent may open before another. These imbalances should be considered when designing the restraints for resisting recoil forces.

Knowing the duration of the recoil forces can aid in the design of certain support structures for vented vessels. The duration calculated by the following equation will be conservative:

$$t_R = (10^{-2})\, K_{st}\, V^{1/3}/AP_{red}$$

Where
t_R is the duration of the pulse, in seconds,
K_{st} is the dust explosibility characteristic, in bar m s^{-1}
P_{red} is the maximum reduced explosion over-pressure, in bar
A is the physical area of the vent, in m^2
The impulse transmitted by the recoil force can be approximated by a rectangular impulse equal in area to the recoil force-time variation. The height of this rectangular impulse i.e. the effective force F_R, is given, by –

$$F_R = 0.52 \times 119 \times A \times P_{red}$$

The impulse transmitted by the recoil force is given approximately by

$$\mathbf{I_R = F_R \times t_R}$$

Where I_R is the impulse, kNs.

A5.12 Specification of Explosion Relief System

The provision of an explosion relief (venting) system is the most common form of explosion protection used in the malting industry.
DSEAR requires that the basis for the design be documented.
The factors that have to be considered are summarised below.

(A) Flammability Characteristics of Material

(1) What values of Kst and Pmax are used in calculations?
(2) Are data based on tests on material being processed or on published (generic) information? If the latter are used, how is this justified?

(B) Mechanical Strength of Equipment

(1) What is the mechanical strength of the equipment i.e. what internal explosion pressure can it withstand?
(2) Is the value based on -
(i) pressure resistant criteria i.e. no deformation in the event of an explosion?
or
(ii) pressure shock resistant criteria i.e. deformation could occur but vessel would not rupture?
(3) Have all connections been included in strength specification (e.g. flanges, door catches, flexible components etc.)?
(4) Which calculation methods have been used?

(C) Vent Area

(1) Which calculation method has been used?
(2) Does vent area calculation take account of:
(i) discharge duct on clean side of vent?
(ii) effect of directly connected vessels?
(iii) excessive turbulence should this be present?
(iv) location of ignition source in the vessel?
(v) internal obstructions within the vessel?
(vi) obstructions near the open end of the duct?

(D) Vent Opening Pressure

(1) What is the type of vent opening (e.g. bursting disc, rigid panel etc.)?
(2) What is the opening pressure - how was it determined?
(3) What is the mass of vent opening? It should not exceed 10kg/m^2 without justification.
(4) Is the vent opening hinged? Hinged panels require expert advice as the fastening, hinge location and moment of inertia of the panel affect the performance.
(5) Will the vent opening become detached and fly free when it vents? Will any restraints be adequate?
(6) What consideration has been given to factors that could impede efficient venting?
e.g.
(i) rigid panel blocking discharge duct?
(ii) weather sealing / protection?
(iii) snow /ice on outside vents?
(iv) any other factors?

(7) How will the vent be replaced, and by whom? Are they competent to carry out the work?

(E) Vent Location

(1) Is the vent located in such a place that flame / pressure from an explosion in any part of the volume has unimpeded access to it (e.g. not impeded by filter bags)?
(2) Is there an adequate unrestricted volume for the vented gases?
(3) Does the vent go directly to the outside of buildings? It is usually unacceptable to discharge an explosion vent into an occupied building.

(F) Safe Discharge Area

(1) Does the vent discharge to an area safe with respect to
- **(i)** protecting personnel and safety-critical equipment from flame, hot gases and pressure?
- **(ii)** protecting adjacent buildings from unacceptable damage?
- **(iii)** emitted flame or burning powder not initiating secondary fires or explosions?
- **(iv)** shrapnel/flying debris from the vent opening?

(G) Reaction Forces on Plant

(1) What reaction forces will the installation experience?
(2) How is the installation designed to withstand such forces/impulses?

APPENDIX 3

Further informative reading for Competent Persons:

(1) Dangerous Substances and Explosive Atmospheres Regulations 2002 S1 2002/2776 HMSO

(2) Design of plant, equipment and workplaces. Dangerous Substances and Explosive Atmospheres Regulations 2002. Approved Code of Practice and guidance L134 HSE Books 2003 ISBN 0 7176 2199 5

(3) Dangerous Substances and Explosive Atmospheres Regulations 2002. Approved Code of Practice and guidance L138 HSE Books 2003 ISBN 0 7176 2203 7

(4) Safe handling of combustible dusts: Precautions against explosions HSG103 HSE Books 1994 ISBN 0 7176 0725 9 (Revised 2004)

(5) Draft European Standard: EN 14491 "Dust Explosion Venting Protective Systems" July 2002. Available ex Br. Std. Inst.

(6) BS 5959 "Control of Undesirable Static Electricity Parts 1 & 2" Br. Std. Inst. (1991).

(7) "Electrostatics - Code of Practice for Avoidance of Hazards from Static Electricity" PD CLC/TR 50404 : 2003. Available from Br. Std. Inst.

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(10) John Barton "Dust Explosion Prevention and Protection - A Practical Guide" Inst. Chem.Eng. (2002).

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(13) Five steps to risk assessment Leaflet INDG163 (rev1) HSE Books 1998 (single copy free or priced packs of 10 ISBN 0 7176 1565 0)

(14) The idiot's guide to CHIP 3: Chemicals (Hazard Information and Packaging for Supply) Regulations 2002 Leaflet INDG350 HSE Books 2002 (single copy free or priced packs of 5 ISBN 0 7176 2333 5)

(15) Energetic and spontaneously combustible substances: Identification and safe handling HSG131 HSE Books 1995 ISBN 0 7176 0893 X

(16) Storage of dangerous substances. Dangerous Substances and Explosive Atmospheres Regulations 2002. Approved Code of Practice and guidance L135 HSE Books 2003 ISBN 0 7176 2200 2.

(17) Safe use and handling of flammable liquids HSG140 HSE Books 1996 ISBN 0 7176 0967 7.

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(20) Small-scale use of LPG in cylinders Chemical Information Sheet CHIS5 HSE Books 1999.

(21) Fire safety: An employer's guide (Home office, Scottish Executive, Department of the Environment (Northern Ireland) for HSE) HMSO 1999 ISBN 0 11 341229 0.

(22) The Management of Flammable and Explosive Atmospheres in The Scotch Whisky Industry, available from SWA (phone 0131 229208) cost £90.

(23) IEC 61508 "Functional safety of electrical/electronic/programmable electronic safety-related systems", Parts 1, 2, and 3.

(24) IEC 61511 "Functional safety - Safety instrumented systems for the process industry sector".

(25) Rolf K. Eckhoff, "Dust Explosions in the Process Industries", 3rd Edition, Butterworth-Heinemann, (2003).

END

Appendix 4 - Dust Concentration Assessments

Barley- Conveyors

DSEAR Dust Concentrations in Conveyors Handling Barley												
Equipment Reference	Equipment area	Equipment Type	Product Handled	LEL (g/m^3) - MAGB DSEAR guidelines	Test date	Sample reference	Monitor ref	Duration (Mins)	Airflow rate (litres/min)	Total mass of particulate (g)	Dust Burden (g/m^3)	Original SML/MAGB DSEAR zoning
C103	Main silo top floor feed in point to conveyor	Chain & Flight Conveyor	Barley	40	12/01/2010	Boortmalt 002/10	GAST 1023 47030	60	100	0.002	0.0003	22
Conveyor C1/2	Old Intake	Chain and Flight	Barley	40	02/05/2007	Muntons 002/09	GAST 1023-101Q G608 NEX	60	100	1.01628	0.17	22
222	Intake 4	Conveyor	Barley	40	27/11/2009	Crisp DEH3581/4	SKC Aircheck 224-52	19	1.978	0.232	6.112	22
222	Intake 4	Conveyor	Barley	40	27/11/2009	Crisp DEH3581/6	SKC Aircheck 224-52	20	1.995	0.396	9.924	22

Boortmalt- Convevor C103

Crisp- Intake 4 Convevor

Comments

The dust concentration within three barley conveyors was measured. The highest concentration was found when unscreened barley was being conveyed without dust extraction. However the concentration was still found to be less than ¼ of the LEL.

Barley - Elevators

DSEAR Dust concentrations in Elevators Handling Barley												
Equipment Reference	Equipment area	Equipment Type	Product Handled	LEL (g/m^3) - MAGB DSEAR guidelines	Test date	Sample reference	Monitor ref	Duration (Mins)	Airflow rate (litres/min)	Total mass of particulate (g)	Dust Burden (g/m^3)	Original SML/MAGB DSEAR zoning
E113	Main silo ground floor feed to boot of elevator	Belt & Bucket elevator	Barley	40	12/01/2010	Boortmalt 003/10	GAST 1023 47030	60	100	Below detectable level	Below detectable level	22
EB1	Blythes	Belt and Bucket	Barley	40	21/12/2009	Bairds 003/09	1023 - 101Q - SG 608X	60	100	2.049	0.340	22
E172 / 3 PIT	Barley Jumbos	Belt and Bucket	Barley	40	04/01/2010	Bairds 006/10	1023 - 703Q - ER 56X	60	100	10.758	1.780	22
Elevator E1/1	Old Intake	Belt and Bucket	Barley	40	02/05/2007	Muntons 001/09	GAST 1023-101Q G608 NEX	60	100	0.77135	0.13	22
0002	Intake 1	Elevator	Barley	40	27/11/2009	Crisp DEH3581/1	SKC Aircheck 224-52	13	1.986	0.173	6.55	22
0002	Intake 1	Elevator	Barley	40	27/11/2009	Crisp DEH3581/2	SKC Aircheck 224-52	21	2	0.247	5.881	22
0223	Intake 4	Elevator	Barley	40	27/11/2009	Crisp DEH3581/3	SKC Aircheck 224-52	19	1.996	0.33	8.686	22
0223	Intake 4	Elevator	Barley	40	27/11/2009	Crisp DEH3581/5	SKC Aircheck 224-52	20	1.999	0.338	8.457	22
E2 elevator	Bly Dresser area - inside building	Belt & Bucket elevator	Barley	40	02/12/2009	Simpsons 001/09	GAST 1023 101Q SG608X	60	50	Below detectable level	Below detectable level	22
E1 elevator	Bly Dresser area - outside east of building	Belt & Bucket elevator	Barley	40	02/12/2009	Simpsons 002/09	GAST 1023 101Q SG608X	50	50	12.35661	4.94	22
E4 elevator	Jumbo Silo area - top LHS Jumbo Road	Belt & Bucket elevator	Barley	40	02/12/2009	Simpsons 006/09	GAST 1023 101Q SG608X	20	50	Below detectable level	Below detectable level	22
0002	Intake 1	Belt & Bucket	Unscreened Barley	40	20/01/2011	CM008	1023 47030	20	80	9.73	6.08	22

Comments

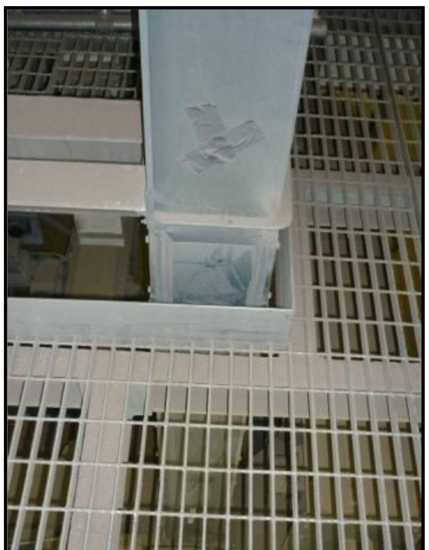
The dust concentration within numerous barley elevators was measured. The highest concentration was found when unscreened barley was being elevated without dust extraction. However the concentration was still found to be less than ¼ of the LEL

Boortmalt- Elevator E113

Bairds- Elevator EB1

Bairds- Elevator E172/3

Crisp- Intake 1



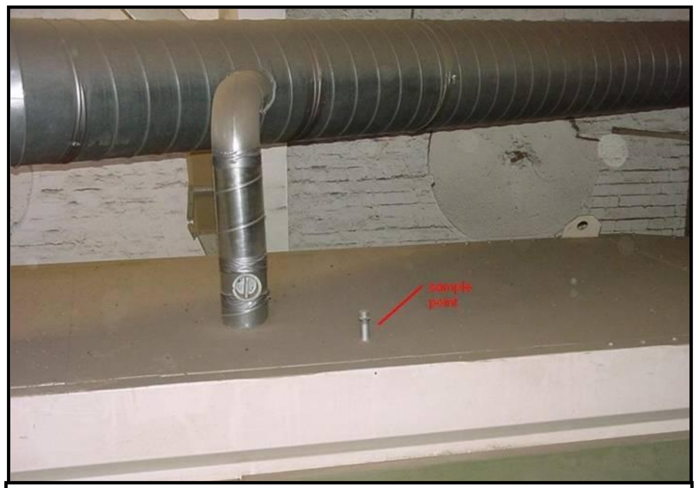
Simpsons- E2 Elevator

Simpsons- E1 Elevator

Simpsons- E4 Elevator

Barley- Other

DSEAR Dust concentrations in Other Barley Handling Equipment												
Equipment Reference	Equipment area	Equipment Type	Product Handled	LEL (g/m^3) - MAGB DSEAR guidelines	Test date	Sample reference	Monitor ref	Duration (Mins)	Airflow rate (litres/min)	Total mass of particulate (g)	Dust Burden (g/m^3)	Original SML/MAGB DSEAR zoning
Intake Pre-cleaner	Old Intake	Dresser	Barley	40	03/05/2007	Muntons 003/09	GAST 1023-101Q G608 NEX	60	100	0.0007	0.0001	22
Intake Pit	Old Intake	Enclosed pit	Barley	40	02/05/2007	Muntons 010/09	GAST 1023-101Q G608 NEX	60	100	1.01628	Below detectable level	22
0059	No 5	Rotary Screen	Unscreened Barley	40	20/01/2011	CM010	1023 47030	60	80	0.008	0.001	S



Crisps- Rotary Dresser

Comments

The concentration of dust was measured within three areas where barley dust could be expected to be in high concentration. The concentrations of dust found were very low in all instances. It is believed this was because dust extraction was utilised on all of the equipment analysed.

Malt- Conveyors

DSEAR Dust Concentrations in Conveyors Handling Malt												
Equipment Reference	Equipment area	Equipment Type	Product Handled	LEL (g/m^3) - MAGB DSEAR guidelines	Test date	Sample reference	Monitor ref	Duration (Mins)	Airflow rate (litres/min)	Total mass of particulate (g)	Dust Burden (g/m^3)	Original SML/MAGB DSEAR zoning
Conveyor C71	Intake Stow	Chain and Flight	Malt	40	05/02/2008	Muntons 011/09	GAST 1023-101Q G608 NEX	60	80	2.8505	0.6	22
C111	Main silo top floor feed in point to conveyor	Chain & Flight Conveyor	Malt	60	13/01/2010	Boortmalt 004/10	GAST 1023 47030	60	100	Below detectable level	Below detectable level	22
Conveyor C61	Screening	Chain and Flight	Malt	60	03/05/2007	Muntons 004/09	GAST 1023-101Q G608 NEX	60	100	0.26746	0.04	22
Conveyor C13	Kilns	Chain and Flight	Malt	60	03/05/2007	Muntons 005/09	GAST 1023-101Q G608 NEX	60	100	0.70353	0.12	22

Comments

The concentration of dust was measured within four malt conveyors. The concentrations of dust found were very low in all instances. It is believed this was because dust extraction was utilised on all of the equipment analysed.

Boortmalt- Conveyor C111

Malt - Elevators

DSEAR Dust Concentrations in Elevators Handling Malt												
Equipment Reference	Equipment area	Equipment Type	Product Handled	LEL (g/m^3) - MAGB DSEAR guidelines	Test date	Sample reference	Monitor ref	Duration (Mins)	Airflow rate (litres/min)	Total mass of particulate (g)	Dust Burden (g/m^3)	Original SML/MAGB DSEAR zoning
E114	Main silo elevator pit feed to boot of elevator	Belt & Bucket elevator	Malt	60	12/01/2010	Boortmalt 001/10	GAST 1023 47030	60	100	Below detectable level	Below detectable level	22
Elevator 606	Malt Plant House	Belt and Bucket	Malt	60	21/12/2009	Bairds 001/09	1023 - 101Q - SG 608X	60	100	3.448	0.580	22
Conveyor 619 - 618	Malt Plant House	Belt and Bucket	Malt	60	21/12/2009	Bairds 002/09	1023 - 101Q - SG 608X	60	100	0.133	0.022	22
E3 elevator	Malt Storage Complex - adjacent Loading Out area	Belt & Bucket elevator	Malt	60	02/12/2009	Simpsons 005/09	GAST 1023 101Q SG608X	60	50	Below detectable level	Below detectable level	22
0519	No. 19 Outload	Belt & Bucket	Malt	60	20/1/2011	CM011	1023 47030	45	80	0.56	0.156	22
0343**	Deculm to No. 19	Belt & Bucket	Malt	60	20/1/2011	CM012	1023 47030	60	80	7.63	1.59	22
0326**	Deculm to silo	Belt & Bucket	Malt	60	20/1/2011	CM013	1024 47030	60	80	16.39	3.4	22
ME1 elevator	Malt Storage Complex - adjacent to AB1	Belt & Bucket elevator	Malt and culm	60	02/12/2009	Simpsons 007/09	GAST1023 101Q SG608X	60	50	0.39301	0.13	22
Conveyor 3/Elevator 3	Roast House	Belt and Bucket	Roast House Malt	60	04/01/2010	Bairds 004/10	1023 - 703Q - ER 56X	60	100	Below detectable level	Below detectable level	22
Bin to CE 5	Roast House	Belt and Bucket	Roast House Malt	60	04/01/2010	Bairds 005/10	1023 - 703Q - ER 56X	60	100	0.400	0.070	22

Comments

The concentration of dust was measured within numerous malt elevators. The concentrations of dust found were low in all instances. It is believed this was because dust extraction was utilised on the majority of the equipment analysed.

** no dust extraction

Boortmalt- Elevator E114

Bairds- Elevator 606

Bairds- Convevor 619-618

Simpsons- Elevator E3

Simpsons- Elevator ME1

Bairds- Elevator E3

Malt - Other

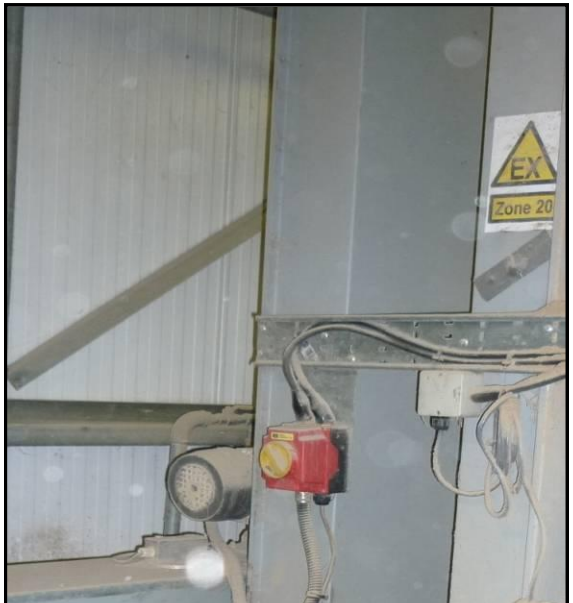
DSEAR Dust Concentrations in Other Malt Handling Equipment												
Equipment Reference	Equipment area	Equipment Type	Product Handled	LEL (g/m^3) - MAGB DSEAR guidelines	Test date	Sample reference	Monitor ref	Duration (Mins)	Airflow rate (litres/min)	Total mass of particulate (g)	Dust Burden (g/m^3)	Original SML/MAGB DSEAR zoning
Bulk Outloading	Bin	Bin	Malt	60	04/02/2008	Muntons 007/09	GAST 1023-101Q G608 NEX	60	80	0.01096	0.0023	22
Malt Dresser	Dresser		Malt	60	04/02/2008	Muntons 009/09	GAST 1023-101Q G608 NEX	60	80	Below Detectable Limit	Below detectable level	22
Under Kiln	GKV underbed		Malt and culm	60	03/05/2007	Muntons 006/09	GAST 1023 101Q SG608X	60	100	Below detectable level	Below detectable level	20

Comments

The concentration of dust was measured within three areas where malt dust could be expected to be in high concentration. The concentrations of dust found were low in all instances.

Malt & Barley Dust (Fines)

DSEAR Dust Concentrations in Equipment Handling Malt & Barley Dust												
Equipment Reference	Equipment area	Equipment Type	Product Handled	LEL (g/m^3) - MAGB DSEAR guidelines	Test date	Sample reference	Monitor ref	Duration (Mins)	Airflow rate (litres/min)	Total mass of particulate (g)	Dust Burden (g/m^3)	Original SML/MAGB DSEAR zoning
DE1 elevator	Pellet Mill Plant - inside	Belt & Bucket elevator	Malt & Barley dust (fines)	40	02/12/2009	Simpsons 004/09	GAST 1023 101Q SG608X	60	50	0.00383	0.001	20
DE3 elevator	Pellet Mill area - adjacent to Dust Bin	Belt & Bucket elevator	Malt & Barley dust (fines)	40	02/12/2009	Simpsons 003/09	GAST 1023 101Q SG608X	60	50	Below detectable level	Below detectable level	20
Cuber	Cuber		Malt & Barley dust (fines)	40	04/02/2008	Muntons 008/09	GAST 1023 101Q SG608X	60	80	0.01455	0.003	20
Cyclone	Intake Building	Cyclone	Malt & Barley dust (fines)	40	05/02/2008	Muntons 011/09	GAST 1023 101Q SG608X	60	80	0.49564	0.1	20
0721	No 5 Lean-to	Belt & Bucket	Malt & Barley dust (fines)	40	23/06/2010	CM001	1023 47030	60	80	28.4	5.9	20



Simpsons- Elevator DE1

Simpsons- Elevator DE3

Comments

The concentration of dust was measured within five pieces of equipment that handle malt and barley fines. The concentrations of dust found were low in all but one instance and even this was considerably lower than the LEL.

Appendix 5 - Case Study – Explosion – Maltings Malt Storage Area

Background

The maltings, located in Belgium, is a 1970's Saladin box type of c.65,000 tonnes annual malt production, built on a canal side site which had existing open plan flat stores which were adapted for malt storage. The flat stores totalling in excess off 18,000 tonnes malt storage were filled from overhead via a belt & bucket elevator and chain & flight conveyor system. The flat stores initially emptied at one end by gravity to an open belt conveyor in a totally enclosed underground conveyor passage, once the gravity discharge reached the angle of repose, a skeletal design scraper conveyor 'transracleur', which was suspended on a wire rope pulley, system would be lowered to pull the malt to the discharge end of the store, this same principle was used in reverse during the filling stage to level the stores and maximise capacity. With all this free falling malt, open scraper conveyors and underground open belt conveyors with absolutely minimal aspiration, dust and dust layers were a major problem.

The very high dust levels and dust layers combined with un-controlled smoking and hot work, and the total lack of awareness from the workforce of any risk presented by the presence of the dust was a major explosion just waiting to happen.

Improvements

The awareness of the work force was raised, with video evidence of the consequences of dust explosions being shown. Smoking was controlled and limited to approved external areas. Hot work was controlled in all areas by permit to work, with an additional level of control for work in dry areas (i.e. malt & barley stores and handling systems, kilns, dressing, dispatch areas etc.) which required central H&S approval of a method statement before a permit could be issued.

Electrical systems were replaced and/or improved, with the provision of rotation detection, sequencing and PLC control. Hard wire testing and thermo graphics were also introduced.

The underground open belt conveyor was replaced by totally enclosed chain and flight conveyors, with aspiration provided by externally sited reverse jet filter units which also provided aspiration to existing conveyors and elevators. A central vacuum system was hard piped to the storage and handling areas to provide an in place cleaning system to ensure dust levels were kept to a minimum. The zoning was completed as per the MAGB DSEAR guide and the new machines and components were ATEX compliant.

The Incident

AM-Whilst moving malt from the analysis bins to the main silo storage area, buckets in elevator E2 were heard to be scraping on the leg. Engineers tensioned and aligned the belt, there was also a cleaning gang working in the large elevator pit which housed E2 along with other malt elevators.

PM – The malt movement was resumed with E2 now tensioned and aligned, it was subsequently noticed that E2 was now making a different noise, upon investigation the noise was traced to an inspection hatch the lip of which had been caught by a bucket and

been bent inwards and was now being hit by each bucket in succession. E2 was again stopped and it was decided to cut the offending lip off to prevent it happening again. The small metal protrusion (approx two inches long by half an inch wide) was jig sawed off by the engineers. At around 1600hrs the elevator was run on test without malt for 10 – 15 minutes and was running silent. The inspection hatch was replaced and the elevator put back in sequence and handed back to production.
1700hrs – The malt movement was resumed with the elevator running silent, the operator checked the movement was running satisfactorily and reaching the destination silo, he then went off to weigh out a delivery vehicle. At about 1730hrs he exited the malt silo area and was walking to the weighbridge, he heard a series of explosions and turned round to see a fireball coming from the malt silo control room area.

Investigation

The dust explosion had propagated throughout the full extent of the malt silo and dispatch conveying system, it had reached all areas, below ground in the conveyor trench, up to the elevator heads and into metal analysis silos which blew apart. The explosions and subsequent fireball which spread through the general workings areas, ripped metal cladding from elevator towers, shattered corrugated roofing sheets and melted plastic safety signs, the destruction was quite complete. Miraculously not a single person was injured in the slightest!
The incident was investigated by forensic investigators Burgoyne, the damage was such that even they were unable to be totally conclusive about the exact cause of the explosion.

- E2 elevator which had undergone maintenance and adjustment that day was suspected to be the cause of the initial explosion.
    - Jig sawing is generally accepted as a cold method of cutting if carried out with a sharp blade, examination of the cut site showed no sign of excessive heat.
    - The metal elevator buckets had been scraping and knocking, friction as we know can cause heat or sparks, adjusting the belt may have lead to later bearing failure producing an ignition source.
    - Men had been working in the elevator pit, maybe an illicit cigarette was left burning.
    - The explosion happened after E2 had been run on test, and after the operator had started to use it to move malt.
    - During the investigation it was noticed that the analysis silo from which the malt was being run had only just run empty, as there was still malt in the conveying system further down stream. Generally the last slug of grain from a silo can contain higher levels of dust and light material, it is possible that this last slug presented higher than normal dust levels thus giving rise to an explosive concentration.

Discussion

The explosion propagated through the whole conveying system, even via conveyors and elevators that were not running.

- The maze of spouts, pipes, slides diverter valves, etc. all to provide built in redundancy for critical movements, in this case worked against us, providing a route (and often an alternative route) for the explosion to move through

There was limited explosion relief fitted, but not enough to vent the explosion, furthermore, there was no explosion isolation it just moved from machine to machine

- The explosion managed to travel along chain and flight conveyors, screw conveyors, it travelled up elevators, connecting spout work and through the aspiration ductwork nothing seemed to prevent the spread.
- The pressure generated by the exploding dust turned a normal square cased Redler chain and flight into a tube shape.
- The damage was greater to the new machines, which were totally enclosed with sealed tight fitting lids and slides, the older machines with loose fitting lids and less substantial construction allowed the explosion to vent more easily, as the casings split apart or lids lifted
- There was no separation or blocking between machines
- There was no chemical suppression fitted.

Dust on inaccessible ledges, and high level roof beams and structures was also roused during the initial explosions and gave rise to secondary explosions in the general walkways and working areas.

Subsequent Actions

- Review all conveyor routes and rationalise, remove as much interconnecting spout work as possible, dedicate routes and remove complexity.
- Review cleaning arrangements and introduce weekly documented hygiene audits.
- Out source ATEX/DSEAR gap analysis and subsequent explosion protection plans to experienced competent specialist consultants (Phoenix Loss Prevention).
- Use modern best practice technology to prevent potential ignition sources, i.e. plastic elevator buckets, belt slip indication, belt alignment detection etc
- Prevent explosion propagation, provide inter machine isolation by best proven technology for the particular application, i.e. explosion relief, blocking worms, rotary seals, slam shut valves, spark detection and chemical suppression.